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Resolving the Strategic Gap in Environmental Management: Tropospheric Ozone In Bedfordshire

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Abstract

Present approaches used in environmental management are typified by a reliance on technical and economic tools within a segregated top-down institutional framework. This is ill suited to cope with a whole breed of problems that impact on common environmental resources and are the result of the widespread and legitimate activity of the majority of individuals within society. These have been termed as "no technical solution problems".

Tropospheric ozone is a good example of such a problem. The main source of the pollutant is diffuse and distant from its impact. The form the pollution event takes shows spatial and temporal variation. It is also to a great extent a result of the use of the motor-car which is not usually an activity in for its own sake but a supporting feature of common life-styles. Policy needs to be able to identify the social requirements of the activity which may vary in among populations and represent this variation by recognising the needs and desires of a wide range of the public.

The thesis proposes that the main problem for environmental management is not the lack of scientific knowledge or regulatory clout, but how modern society has been managed with regard to its impact on environmental resources. It argues that the paradigm of interdisciplinarity is necessary tool for bridging what can be seen as a distinct strategic gap between the present institutional culture in air quality management and the social and physical environments it aims to influence.

This proposition is supported by investigations into the quantitative and qualitative nature of those social and biophysical processes which are responsible for the generation, transportation and impact of tropospheric ozone. The thesis concludes by proposing a novel strategic framework the management of this pollutant based on the need to identify and communicate issues inherent to the social and physical aspects of the problem, as well as the resolution of conflicts arising from them.

Acknowledgements

Well one wonders where to begin, so I'll be traditional:

Massive thanks to my supervisor Mark Lemon for his help and encouragement (but not his coffee). Mark has been invaluable to this thesis and I take this opportunity to let him know that I have considered his supervision to be both encouraging and at times inspirational. I would never have got this done without you lad!

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However away from the dizzy world of Cranfield I feel I need to offer thanks, apologies and flutter my eyelids at my beautiful wife Ineke Keizer whose sheer tolerance has been breath taking.

Finally acknowledgments and kisses to my daughter Miranda who is the truest inspiration of all.

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Glossary and Abbreviations

μgm, microgrammes = 10^{-6} g.

μm, micrometers = 10^{-6}.

ANOVA, analysis of variance.

AQM, Air Quality Management.

AQMA, Air Quality Management Areas.

AQS, Air Quality Standards.

CEC, Commission for the European Community.

Common property. Goods or resources not owned by an individual or interested party.

Cost benefit analysis. An economic technique for estimating the desirability of a proposed course of action, in which the advantages and disadvantages are listed, expressed in monetary terms and the totals compared.

DoE. The Department of the Environment, (now the Department of the Environment, Transport and the Regions).

DTP/DOT. Department of Transport, (now the Department of the Environment, Transport and the Regions).

DTi. Department of Trade and Industry.

EA. Environmental Assessment.

EC. European Community.

Emergent behaviour. Collective behaviour resulting from an action, policy or intervention that was not predicted or intended to result from that intervention.

Emergent phenomena. Essentially synonymous with the concept of third world phenomena, where unpredictable and unintended relationships and consequences may come into being due to unforeseen or unintended interactions between sub-components of the socio/biophysical system.

EPA. Environmental Protection Act (1990).

EU. European Union.

Invisible hand theory. The every individual, in pursuing only their own selfish good, will be led, as if by an invisible hand, to achieve the best good for all, so that any interference with free competition by government was almost certain to be injurious.

Integrated Pollution Control IPC An attempt in regulation and policy design to move away from the medium based approach implicit in UK environmental law to one of a system of control where authorisation of process needs to take account of the effect that process has on all environmental media.

LSD test, Least significant difference.

NETCEN. The National Environmental Technology Centre.

nm, nano meters = 10^{-9} meters.

NMVOC. non methane organic compounds.

NOx. Nitrogenous Oxides,

Percentile approach. A stated specific level of compliance. Data sets of the compliance values are listed in ascending order, the stated percentage of values must fall below compliance level. E.g. if a value is counted as a 15 minute reading then in one years there are 365 x 24 x 4 readings (= 35040). To achieve a stated aim of a 99 percentile then all but 1% of these reading need to be below compliance level. Or to put it another way 1% (i.e. 35) of these reading may be over the compliance value without breaking the guideline.

Planning Policy Guidance Notes (PPG's) official guidelines published by central government for practice at local government level. Although not implemented by law are strongly advocated as being enacted upon.

ppb. parts per billion (10^9).

ppm. parts per million (10^6).

Prisoners Dilemma. A situation in which , although rational self interested action by individuals produce social outcomes not desired by them, there are no incentives for them to behave in any other way.

SoS. Secretary of State.

Strategic Gap. A condition of imbalance between what an organisation is and what it would like to be with regard to its aspirations.

Third world phenomena. A term coined in early economic literature to indicate a result of a situation that while being brought about by human activity, is not the result of any human intent (see also emergent phenomena).

Transport Policy and Programme Report. Statements of the objectives and policies which local authorities plan to pursue in their area. Not statutory.

UKNAQS UK National Air Quality Strategy (DoE 1997).

Utility Function. Used here to express an aspect of an individual's well-being, the term is used to encompass more than economic gain or security, but also feelings of happiness derived from belonging, feeling safe, aesthetic pleasure or being able to carry-out life centred around everyday needs and desires.

1. A Background to Multidisciplinary and Interdisciplinary Approaches to Environmental Management

This chapter will set the aim of the thesis, briefly review some of the traditional approaches in environmental management, and describe their shortcomings. In answer to recognised deficiencies there is an emerging trend in environmental management: away from the end-state oriented rationalist approach to one of a more interdisciplinary, holistic approach capable of viewing and analysing the environment as a complex social and biophysical entity. The latter half of this chapter will describe the lay-out of this study, introduce the problem being broached and describe the area within which the study is based.

> *"Call a thing immoral or ugly, soul-destroying or a degradation of man, a pale to the peace of the world or to the well being of future generations; as long as you have not shown it to be uneconomic you have not really questioned its right to exist, grow and prosper."*
>
> *(E.F. Schumacher, 1973)*

1.1 Introduction

Present approaches used in environmental planning are deeply rooted in the rationalist paradigm of social physics which has dominated the discipline for the last fifty years (Foot 1981). Features that typify this approach are goal-oriented end-state planning (Sperling, 1984), large scale predictive modelling, a reliance on the technical fix approach[1] and the segregation of planning functions between specialist occupations and localities, giving rise to the three broad sectors of transport engineering, land-use planning and environmental health. These approaches are, however, ill suited to cope with a whole breed of problems that are the result of common and legitimate activity of the majority of individuals within a society. They have been termed by Hardin (1968) as "no technical solution problems".

Means of undertaking environmental management in the UK have been placed firmly in the court of either regulation, coupled with penalty imposition for individuals acting in contradiction to regulation (typical of the planning approaches to the urban environment during the 1970s), or the approach of financial incentive and/or disincentives, the so called stick and carrot approach (Barde, Johanes et al. 1994), as espoused by the invisible hand theory (Barry 1988)[2]. This has lead to the development of approaches such as the *polluter pays principle*, environmental taxation, and social and environmental cost benefit analysis (Turner 1995). The approach is essentially top down (Floyd, 1986) in both approach and structure, and firmly based within the rationalist paradigm (Vickers, 1984).

The dominance of these approaches in the planning literature has been compounded by the fact that they have successfully resolved many of the direct issues of localised public health in the face of industrial development in a more or less satisfactory manner

[1] as embodied by concepts such at Best Available Technology Not Entailing Excessive Costs, itself a derivation of the Best Practicable Means approach.

[2] see glossary.

(Ratcliffe, 1992; Ashby and Anderson 1981). However, despite these techniques developed in environmental planning over the last fifty years, and in many cases because of them, we face new as well as lingering problems in the urban environment in terms of social problems and resource degradation (Batty, 1994).

In this thesis, it is proposed that many of the contemporary environmental predicaments we face are a type of problem involving dispersed and synergistic pollutants involving complex, poorly defined and incompletely understood biophysical systems. The causes of the problem are common and legitimate activities of a large majority of individuals which are intricately linked to a person's ability to function in modern society (Taylor 1990).

The result of such a situation is that both the cause and the effect of the pollutant (see chapter 2 & 3), as well as the effectiveness or consequences of any measures taken to mitigate the impacts of the behaviour responsible for the problem (chapter 4), are surrounded by a high degree of uncertainty.

1.2 Problems of Present Approaches to Environmental Management and Planning.

It is proposed that present approaches to environmental management fail to recognise the interelatedness of social systems and the biophysical systems in which they sit as well as the subtle interaction between the two. When one considers the present approach to UK environmental and development policy. However, it can be seen that these new problems of emergent behaviour[3] and resource degradation have had little impact on the institutional form, functioning and policy approach within the process of environmental strategy (see chapter 4), which is still very much based on the division of the world into artificially separate natural and social entities (as is illustrated in policy and guidelines such as those for environmental assessment (DoE 1990; DoE, 1991; DoE, 1992; DoE, 1994). The approach commonly used is single or multidisciplinary (see 1.3) rather than interdisciplinary (O'Riordan, 1995), "science" based, and encompass goal oriented end-state[4] aims (DoE, 1994). Strategies are defined on the basis of technically modelled predictions of what the policy makers, within their own perspective, would like to see, rather than by developing multiple perspective and co-operative futures pathway scenarios. Furthermore the public are often treated as silent recipients of policy within a public welfare rather than participation philosophy (McAuslan, 1980). Policy and responsibility are mainly defined within a spatially and temporally restricted framework (McGlade, 1995) concentrating on administrative structures that often bear little similarity to the physical systems of the problem being broached. The result is a somewhat rigid approach to practice of environmental management and when faced with regional problems of resource degradation resulting from the aggregation of widespread localised action (see chapter 4) it has several failings.

A feature of the emphasis placed on the science based approach to environmental management is that quantitative research tends to receive preference over qualitative

[3] see glossary

[4] see glossary

research,[5] with an over-emphasis on scientific data (Bryman, 1992). While often multi-disciplinary in nature, information obtained during analysis becomes integrated within the restricted perspective of the engineer or 'rationalist planner'. The result is that goals and options tend to be expressed within a restricted agenda which is often far removed from the people it is meant to influence. This is especially important when one considers that the way the public reacts to a policy or programme can have a significant effect on the success of that policy (O'Riordan, 1995; North 1984). A point which may appear obvious but is often poorly recognised in present policy analysis (Ahuja, 1996).

Another problem becomes apparent when one considers that these goals are usually then tested against predicted alternative end-state scenarios (using computer based models, or "expert" analysis). The problems of this approach are grave since it is against such end-states that policies are judged. However, socio-natural systems are typified by their complexity, where emergent features, non-equilibrium, non-linear interactions, uncertainty, and risk are inherent (Sperling, 1984). In the absence of a complete understanding of the processes of urban and environmental co-evolution (Lee 1973; Batty 1979; Saunders and Williams, 1986; Glasson, 1992; Harris 1994), mixed with an often restricted approach to parameter and variable identification, uncertainty is implicit to these models. Calibration and verification of models only reflects past events and processes with any certainty rather than new ones. The process effectively treats a dynamic evolving complex system as a static entity (Viessman, 1988). The result is that large scale experiments are played out on whole geographic regions, often involving long term infrastructure investment without the flexibility or budget to easily correct mistakes (DoE/DoT, 1996). This inherent unpredictability is also heightened by chance catastrophic[6] effects impacting on the system and by a general lack of complete theory in both the subjects of ecology and urban planning. The end-state scenarios against which the suitability of the policy or policy-set is judged are at best unreliable.

This activity of goal setting for policy based on often incomplete "scientific evidence" (e.g. epidemiological or toxicological studies into physiological health effects; ENDS 1992; DoE 1994) has problems when one considers how the wider society reacts. This implicit unreliability in a pluralistic and democratic society where proposed plans or programmes may be in contradiction to other societal aims (see DoE 1996, chapter 6 par. 2), may result in a loss of legitimacy in those proposing the policy or plan causing a distancing between the policy makers and those that the policy intends to influence.

The complexity in what can be seen as the social and biophysical environmental complex (Pablo et al. 1994) leads to another problem with present policy approaches. Social and biophysical structures tend to vary quantitatively and qualitatively across spatial and temporal scales (McGlade, 1995) affecting both the definition of the issue and the available management options from one area to another (see chapter 2). Management institutions tend to be organised in a segregated spatial framework with varying temporal and political agendas reflecting past problems and remits rather than

[5] For example over half of the DoE guidance on environmental assessment of policy (DoE 1991) is devoted to techniques for quantifying the costs and benefits for environmental effects within a restrictive financial accounting framework

[6] Catastrophic is used here to mean any sudden and significant change.

the ones at hand (see chapters 3 & 7). At present in the United Kingdom there is little regional structure for co-ordination of local management approaches (Glasson, 1992; Therivel, 1993; see chapter 3). This results in poor communication between these local levels.

In environmental management where regional structures do exist, the term tends to be defined around historical administrative boundaries, such as the county councils, or legislative boundaries, such as the Environment Agency (e.g. DoE 1990; Department of the Environment 1991; Commission for the European communities 1993; DoE 1994; Countryside Commission 1992). However, regional, meso, and large scale effects can be seen to be a result of emergent local actions (themselves variable) occurring over an area that may vary depending on the issue (dependent on problem specific biophysical flows) against which the assessed policies are being measured (Mulder, 1985, Barry 1988, Stern, 1992). The present boundaries of policy-making institutions (or at least the area of influence) are rigid. However, because the biophysical and social systems are not, management at one level can interfere with the option space of that at another (chapter 2). It will be proposed that a truly strategic approach needs to integrate bottom-up management co-ordinated within a strategic top-down framework. Management structures must be flexible to match changing and emerging social and biophysical issues (chapters 4 & 8).

A final major problem with the present tradition in environmental management is the artificial separation of the social and natural environment into discrete entities, where the representation of the natural environment as an independent optimal system leads to human actions often being viewed as unidirectional impacts (McGlade, 1995). When feedbacks are represented, it is the negative feedbacks (i.e. those that resist change within the system state) that are deemed desirable (e.g. see government guideline on assessing environmental impacts DoE 1992); change in the environment is discounted as being 'bad' and something to avoid. However, all of the UK's natural environment has co-evolved with the human activity it has supported and which it is supported by (McGlade, 1995). Major features of the semi-natural environment that are considered desirable to protect, such as heathland, are the product of human intervention and represent positive feedback between the two sub-systems. The false representation of human activities as unidirectional impacts or undesirable negative feedbacks can be seen to restrict the identification of opportunities for mutually beneficial management options and features (Viessman, 1988).

These problems are important. The present sector and procedure led approach to policy assessment leads to them being approached within a set framework and agenda that is often inapplicable to the context (Healey, 1990). Complex social phenomena are seen as simplified, static recipients of policy (see chapter 4) resulting in a poor connection between the issue being investigated, the procedural framework within which the investigation occurs, and the analytical method used to investigate it (Healey, 1990).

In answer to many of these recognised failings of contemporary methods in policy and management analysis and strategy, there is a new and emerging approach to environmental management and modelling. This method involves the following (Pablo et al. 1994; Sperling, 1984; Duncan and Savage 1989; Kankidou and Crutzen, 1993; Ahuja, 1996; O'Riordan, 1996; Feeny, et al. 1990):

- a move towards a more problem focused (or issue lead) analysis,
- interdisciplinarity (see 1.2),
- looking at future possible pathways as a "what if" exercise,
- incorporating multiple perspectives of different interests,
- a precautionary approach,
- concentration on mutual co-operation, communication and conflict solving.

The aim of these new approaches is seen as the encouragement of competent biophysical and social analysis to supply solutions to problems facing society (Pablo et al. 1994), that are both acceptable and applicable to the value systems of those who are the recipients of policy or change (O'Riordan, 1995; Ahuja, 1996).

1.3 An Introduction to Multidisciplinary and Interdisciplinary Approaches.

The concepts of interdisciplinary and multidisciplinary research are used, in the context of this thesis, to describe the way in which theory and data are integrated to provide insight into the issues being examined. Within the practice of environmental science and management these terms are often used interchangeably. However, within the context of environmental management there is an emerging consensus on a distinction between the two.

Multidisciplinarity was first recognised as being central to the field of environmental assessment in the USA under the auspices of the 1969 National Environmental Protection Act (O'Riordan, 1995). It is held as an answer to the need to assess impacts on all aspects of the "*human and natural environment*" (DoE 1992). This tool approaches the problem by producing what are essentially a group of separate reports carried out by separate disciplinary groups. Amalgamation of these reports tends to occur at the last stage prior to publication, in what is often a checklist or matrix approach (Walthern, 1992; see in figure 1.1).

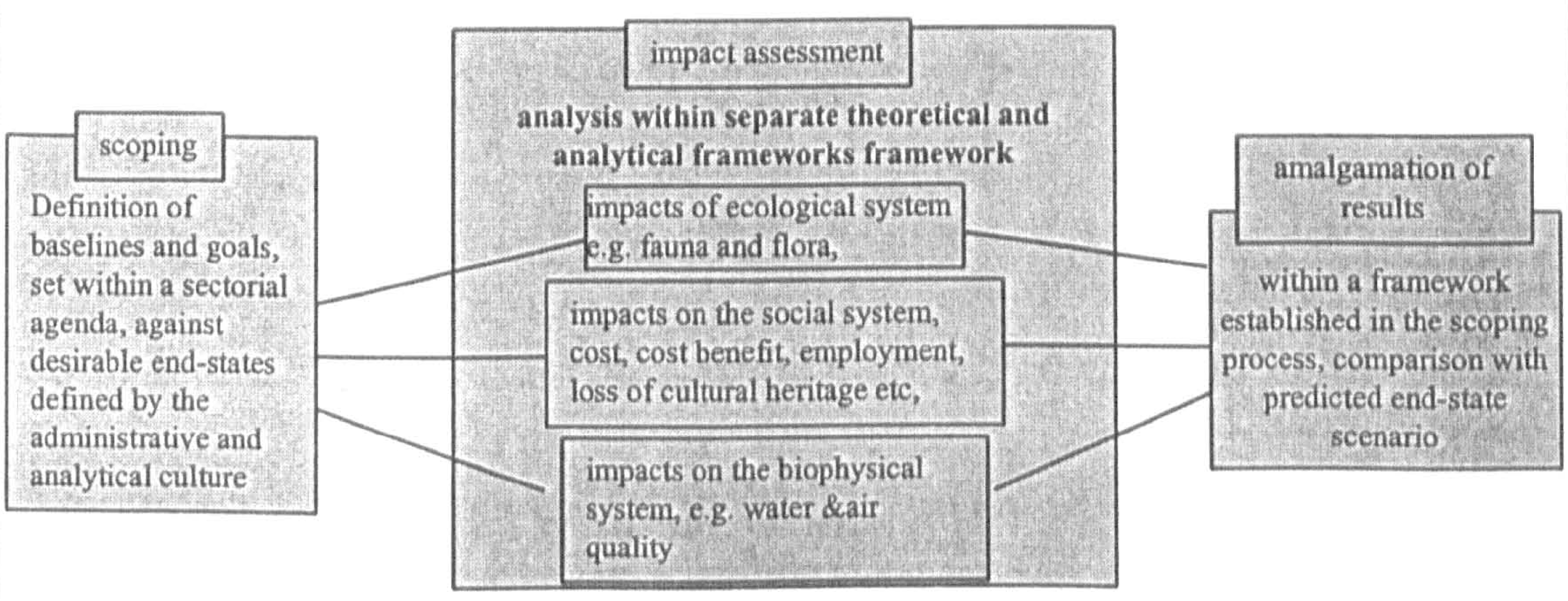

Figure 1-1 The environmental assessment model as a multidisciplinary framework: Goals are set within an existing legislative and analytical framework based on best *scientific* knowledge. Baseline identification and analysis tends to be formulated as separate sub-units of the study, integration of the different disciplinary approaches occurs towards the latter stages of the process (after DoE; 1992).

Although this approach, still commonly used in preparing environmental assessments, is a simplified version of the more advanced techniques in multidisciplinary analysis, such as those employed in environmental economics (O'Riordan, 1996) or road transport emission modelling, the role of multidisciplinarity is essentially restricted to coupling existing models of how different aspects of how society and/or the environment interact within the perspective of the involved professions (Schimmel, 1994).

It is this multidisciplinary approach that forms the standard model for policy assessment and design within the UK environmental sector, and is the approach promoted in the UK White papers *Policy Appraisal and the Environment, (DoE 1991), The Guide to Environmental Assessment (DoE 1992)* and the *UK Air Quality Strategy (DoE 1997).* However, its usefulness has recently come under some criticism for the following reasons:

- This approach has the common feature of integrating information gathered and assimilated within a restricted set of assumptions and values from a restricted range of academic and institutional sub-cultures (i.e. essentially those of the respective scientific disciplines). The goals and aims of end-states or future scenarios of desirable pathways are defined within the perceptions of a small sub-group of the wider society (O'Riordan, 1995).
- By agglomerating disciplines after goal identification and analysis has been carried out, this approach does little to develop an understanding of the interactions between the different features of society and its relationship with the real world. Specifically it fails to develop a model of how changes within society influence the way in which different groups adapt to that change in terms of their behaviour and value sets, and the way in which this influences the form of society and the perception that it has of its biophysical environment (see chapter 4.2).

The result is a situation where the environment is essentially analysed as a static object that receives unidirectional impacts from human action (Viessman, 1988). The approach neglects the complex interaction between resource use and degradation, human behaviour within a social-economic system, political option space and contingency and the complex biophysical system (Pablo et al. 1994). The lack of knowledge can be a severe impediment to an understanding of the issue in terms of root cause, leading to inappropriate mitigation and/or management approaches (O'Riordan, 1996) and an oversimplification of the subtly interrelated features of the socio-biophysical environment (Pablo et al. 1994). In answer to this problem there has been an emergence of a new approach to environmental analysis; that of interdisciplinarity.

The use of *interdisciplinarity* as a tool for environmental management and analysis represents a move away from the multidisciplinary approach. As a central feature, it has a consideration of the influence that different aspects of the whole social and biophysical environment have on each other, and views these systems in terms of common processes and themes (see figure 1.2) in what are seen as mutually co-evolving physical and social systems (O'Riordan, 1995) that form the wider environment (Rambo, 1990)[7]

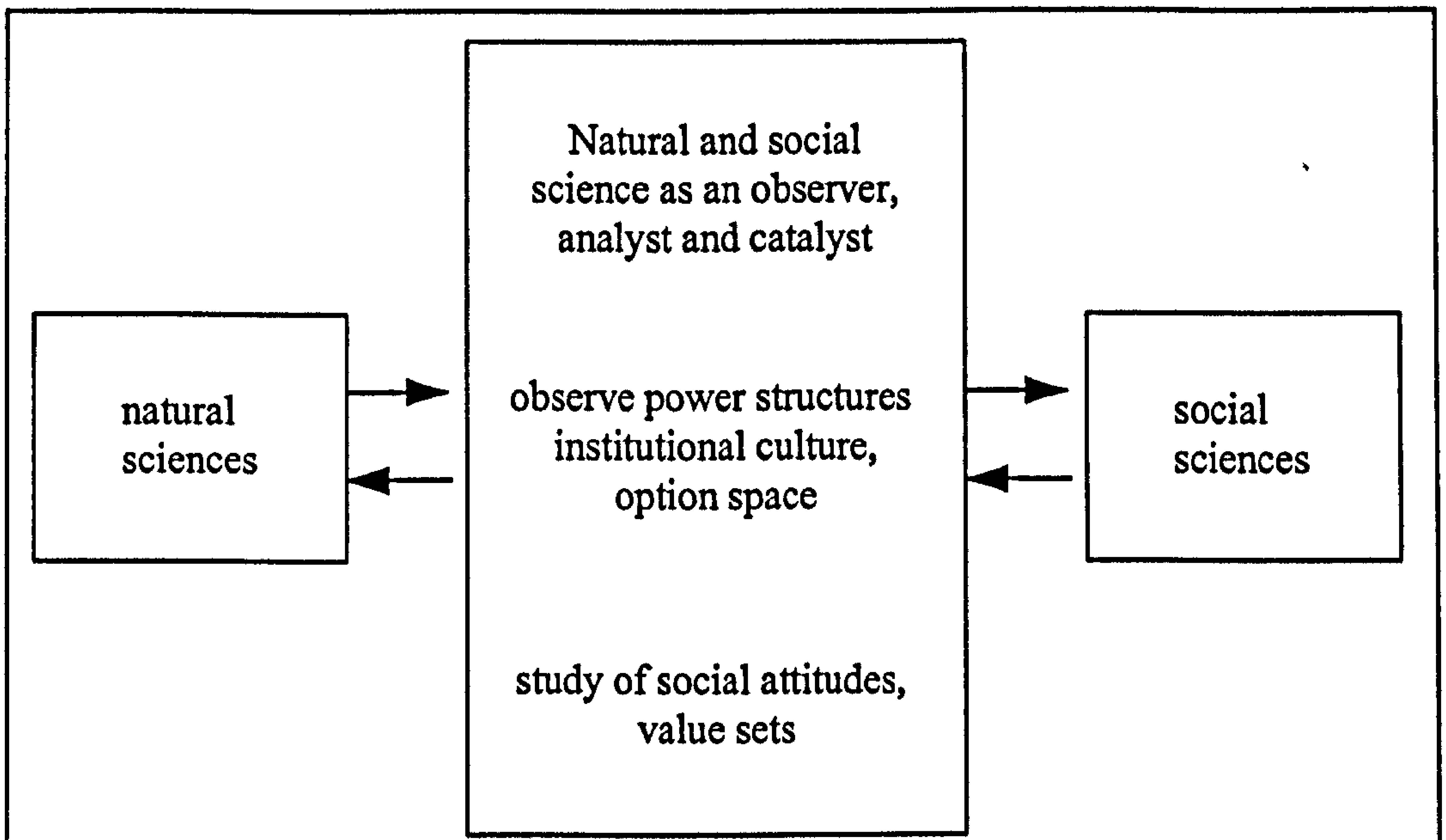

Figure 1-2: An interdisciplinary research design
(after O'Riordan, 1995 Allen et al. 1994 and Ahuja, 1996)

The aim of the approach is to supply the analyst with a framework that can examine the interrelationships between the causes of the problem and the social and biophysical environment in which the problem sits, including how change of any of these parameters may affect others and/or the system as a whole.

To this end an interdisciplinary approach has the following features:

- It views the environment as a system of complex interacting variables and therefore as a first step identifies the need to establish and define the nature of these systems (Pablo et al. 1994). However, to define the environment per se on this basis would be an incredibly difficult task, therefore the approach is to use the problem being investigated as the boundary for study and variable definition. This approach has been termed the "*Environmental Problem*" approach where the environmental problem is *"any anomalous situation which affects the ecological, biophysical or socio-economic quality of the environment"* (Pablo et al. 1994), or the issue-lead approach (Allen, et al. 1994).
- The approach recognises the evolutionary and dynamic nature of the environment, in that social systems can influence biophysical and vice versa giving rise to desirable and/or undesirable feedbacks (McGlade, 1995). It therefore encompasses a pathways approach recognising that change is an implicit feature of environmental systems (Ahuja, 1996) and that the aim of environmental management is to direct and

7 The term environment can therefore be seen to mean the system in which human and natural phenomena react and interact (after Pablo et al. 1994).

accommodate this change away from miasmic outcomes towards more benign outcomes for society as a whole (see chapter 4).

- It also recognises the diverse nature of society; that it is the behaviour within that social system which is often the cause of the problem, and that these behavioural patterns are tightly bound up within a wider culture (Taylor 1990). This produces a need for a more negotiated set of goals and future scenarios, since the response of the recipient population to any programme or policy may significantly affect its outcome (Hutton and Ahtola, 1991; Hedges 1994). The inclusion of a mechanism that can identify these value sets of inherent within the population is a necessary part of any analysis (Ahuja, 1996). A recognition that supports what is essentially a public participatory, rather than welfare approach (McAuslan, 1980) demanding legitimate consultation (O'Riordan, 1996).

1.4 The Scope and Aims of the Thesis

This thesis aims to approach one of these problems of environmental degradation: that of rising levels of road transport-derived tropospheric ozone in Bedford. This case study will be used to show that there is a breed of issue which is subtly complex, unpredictable, and emergent in nature, crossing traditional administrative boundaries (Hadfield, 1997). The pollutant is not a direct anthropogenic emission but the synergistic result of a complex interaction of anthropogenically and naturally emitted precursors in the presence of climatic catalysts (see chapter 2). There is no discrete process and no identifiable intent to pollute and therefore the pollutant represents what has been termed *a third world phenomena* in the economic and political literatures, i.e.;

> *"The result of human activities that come about without any human intent"*
>
> (e.g. Furguson, 1776; Barry 1988; Mengar, 1966)

or in the systems and scientific texts as an emergent phenomena (e.g. Checkland, 1992; Hadfield, 1997, see chapter 4).

In the Bedfordshire area, the problem of ground level ozone is essentially derived from the recent growth in the use of the motor-car (chapter 3.5) which, over the last century has evolved from a luxury item to a major mode of transport. It is now cheap, accessible and widely used (Air Health Strategy 1996; ENDS 1996), a change which represents an ever growing impact on air quality, a non owned environmental commodity or *common property*[8]. This problem can therefore be seen to be a classic example of what has been described as a "*no technical solution*" problem (Hardin, 1968). These have been identified as problems that need a distinct shift in paradigm from one that seeks a technical panacea to one that can achieve change in the actions and values causing the problem. This notion is supported by the fact that most of the literature agrees that the growth rate of the use of the private motor-car will be such that any benefit in air quality achieved by technical controls of emissions will be off-set by traffic growth rates by the year 2010 (DoE, 1997).

[8] see glossary

In answer to this problem, the thesis will approach management of air pollution, not as a technical issue but rather more one of approaching the behavioural cause of car driving. The argument presented is that this problem requires a distinct shift in paradigm, associated strategy, and institutional structures in its management and will especially concentrate on the problems of aligning institutions and strategies within the regional constraints set by the biophysical system under concern (chapter 4) and has as its remit the following aims:

- **To establish a theoretical framework for describing the social and biophysical aspects of the environment and identifying the importance of the linkages between the aspects between and within different scalar resolutions.**
- **To define an integrated conceptual framework for a strategic environmental management of a regional problem of air quality degradation as a result of increasing levels of tropospheric ozone.**

Within this aim the thesis contains the following objectives:

- to describe the problem of ground level ozone in the borough of Bedford in terms of its regional and local social, biophysical, and managerial systems.
- to construct an integrated theoretical framework for describing and analyzing social and biophysical aspects of an emergent pollutant.
- to illustrate the incongruities within the present framework for ground level ozone management and the social and biophysical structures involved in its production.
- to build and describe a strategic framework for the management of ground level ozone based on a recognition of its behaviourally derived nature.

1.4.1 Thesis Structure

The thesis has the structure shown in figure 1.3. It will approach the above task in three main sections:

1.4.2 Part 1: Introduction and Theoretical Framework

This section of the thesis is an introduction to the problem of managing the environment as a co-evolutionary social and biophysical phenomenon and a description of the theoretical framework that will be used to approach it. It consists of the following sections:

Chapter 1 sets the aim of the thesis and introduces the background of approaches to environmental management within which it is set. It essentially argues for a move: away from the end-state oriented rationalist approach traditional in multidisciplinary analysis to one of a more interdisciplinary, holistic approach. The aim is to recognise the complex and dynamic social and biophysical nature of the environment.

Chapter 2 forms a theoretical framework used to describe the relationship between the social and biophysical elements of the environment and how these reconfigure at different resolutions. It specifies the approach to problems of environmental degradation as a social and biophysical issue. Using literatures from the social, managerial and environmental sciences, this chapter illustrates the link between social and managerial systems, the influence these systems have on each other, the co-evolutionary nature of the two, and how these can impact on and be constrained by biophysical systems.

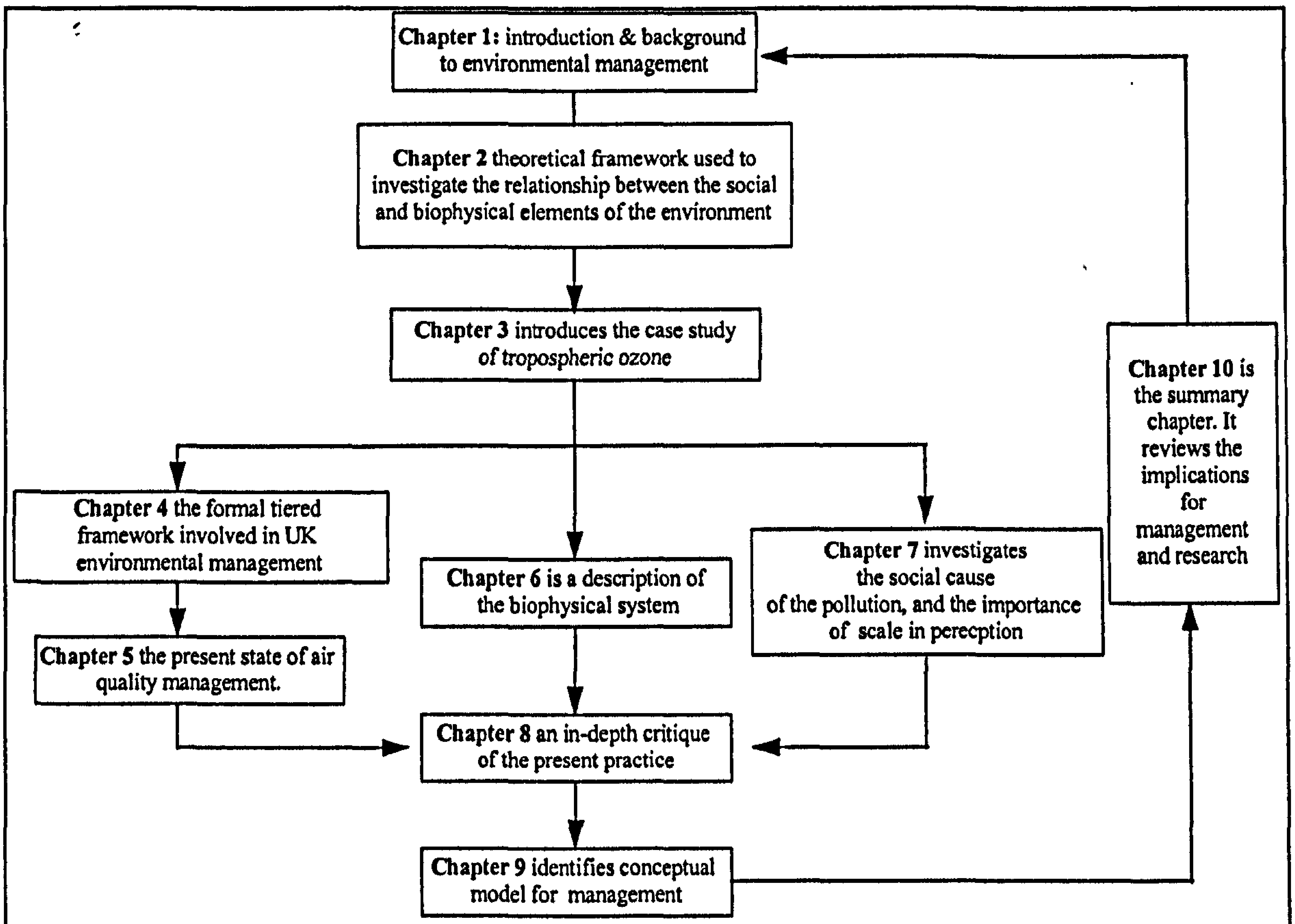

Figure 1-3: Outline of the thesis structure

The chapter explores the concept of interdisciplinarity as a method for mapping social and technical systems while recognising changing issues between different scales. Important aspects are the recognition of the feedbacks between events at different spatial and temporal scales and between social and biophysical aspects of the environment as well as the managerial decision making framework, itself.

It concludes by extending the theoretical framework into the issue of tropospheric ozone. This is shown to be essentially a problem of misalignment between biophysical systems, social needs and desires and managerial systems that have become distant from the two. The rational for the field investigation into the nature of these incongruities is described and a description of the field methodology is reviewed.

Chapter 3 introduces the case study of tropospheric ozone. It explores problems inherent to the management of ground level ozone with regards to its biophysical qualities. The chapter will include a review of the pollutant's precursors and their chemical synergism; a discussion over of the importance of road transport as a source and the derived nature of road transport; as well as an introduction to how the issue changes with respect to social/biophysical and managerial spatial and temporal scales at which the issue is viewed.

1.4.3 Part II : Research exercises

Is a description of the biophysical, social and management systems. The section of the thesis takes on the three main stands relevant to the management of environmental problems in light of the theoretical construct of the environment. They are the biophysical, social, and managerial subsystems. It reviews the way these systems change in relation to scale and how present management approaches aim to communicate these issues.

The section consists of the following chapters:

Chapter 4 identifies the formal tiered framework involved in UK environmental decision making, from the European through to the local government level. It briefly reviews the main players in the UK environmental management process and locates their function and form within a historical context. The latter part of the chapter explores the nature of the relationships between these levels of government and how they have related to public attitudes and values.

Chapter 5 uses primary and secondary interview data and supporting documentation from local authorities to detail the present state of air quality management. It investigates the nature of the explicit values and assumptions within air quality management including a description and an in-depth review of the 1995 Environment Act (part IV), the UK Air Quality Strategy (DoE 1995, DoE 1997) and local authority policy.

The first two research chapters are supported by primary and secondary data covering modern policy development and practice in air quality management. These are:

- Interviews carried out by the author with local authority transport, land-use, environment and environmental health officers in Bedford Borough, and Bedfordshire County Councils. The data is gathered from one hour semi-structured interviews into approaches being explored by the relevant departments as regards to the 1995 Environment Act.
- Data from interviews with Environmental Health Officers, carried out as part of a study into regional monitoring patterns for air pollutants in Bedfordshire and Hertfordshire (Hadfield, 1994).
- A literature and Internet search into development management programmes within UK local authorities.

The data are up to date until the early part of 1997 due to restriction on the time available for the research and is explained more fully in the relevant chapters.

Chapter 6 is a description of the biophysical system. The source of the precursors is identified and the nature of a regional ozone problem in the South Central Region of the UK is described. Changing pollution issues over this area are also identified. The chapter is supported by data from automatic and non-automatic monitoring sites in the area.

Chapter 7 is a description of the social cause of the pollution, i.e. car driving, and a description of the needs and wants which this behaviour fulfils in the region, and how this changes on a sub-regional level. Findings are taken from a wide scale social survey into desires and needs of car users in the region.

1.4.4 Part III: An Air Quality Management Framework

Using the interdisciplinary paradigm, this section of the thesis presents approaches and alternative management techniques and frameworks for fostering communication between these strands of environmental management, as well as between different issues and agenda concerning these strands at different spatial resolution. The aim of this section is to foster a better approach to strategic management that allows for a concise plan that is able to identify the most appropriate form of analysis and action at the most appropriate level.

Chapter 8 pulls together the main findings of the research chapters to form an in-depth critique of the present practice, concentrating on local to national management structures (although input from European legislation is noted). The chapter will concentrate on the scalar variety in issues in the different aspects of transport derived tropospheric ozone as well as the poor mapping of these issues onto the present management structure that holds a remit over air quality. The implications for management are discussed.

Findings are supported by interview data described previously as well as by information gained from observing a workshop attended by a wide range of professionals involved in air quality management in the Bedfordshire region.

Chapter 9 identifies a conceptual model for management aimed at bringing about change in the culture of air quality management. Using approaches adapted from the management, sociology, and social anthropology literatures and illustrated by present examples this section tackles the subjects of integration and subsidiarity and a method for aligning management of the general social and the biophysical systems. The emphasis is on the management conflict between those whose life-styles need to change and those affected by the actions that need changing (O'Riordan, 1995) including the form of change and relevant compensation packages needed to bring the change about in the population.

Chapter 10 is the summary chapter. It reviews the main features of the thesis, its findings, contribution to knowledge and location and suggests areas for further research.

While far this chapter has reviewed the concepts of interdisciplinarity and how it differs from multidisciplinarity, the following chapter will review a region and socially derived environmental problem from an interdisciplinary perspective. The case study used is that of raised levels of transport derived tropospheric ozone. The reasoning behind taking on this problem within this study is that the problem is recognised as showing regional variation in its biophysical issue, it is the product of wide scale legitimate human action and is recognised that there is little scope for its management within present environmental strategy frameworks.

2. Theoretical Framework: An Exploration of the Relationships Between the Social and Biophysical Environments

This chapter constructs and presents a conceptual framework for expressing the environment as a mutually co-evolving composite of social, institutional and biophysical systems. The implication of this conceptualisation for achieving successful environmental management of a disperse and culturally derived pollutant such as ground level ozone will be discussed.

The approach will recognise the need to effect change in behaviour, to achieve the co-ordination of issues and needs between individuals and management institutions as well as between different occupational, geographical and temporal levels within management institutions. The chapter will conclude by justifying the need to identify and describe the implicit and explicit value sets of the social system under study with respect to the behaviour being investigated, the biophysical environment in which it sits and the management institutions within which the agents of change are situated. It will be proposed that the historical neglect of this approach has lead to a system where the management institution is incongruent with both the social and biophysical aspects of the environment which it aspires to manage. In this situation such institutional frameworks need to adopt a programme of cultural transformation.

> *Ruin is the destination to which all men rush, each pursuing his own self interest in a society that believes in the freedom of the commons. Freedom of the commons brings ruin to us all.*
>
> (Hardin, 1968)

2.1 Introduction

While the previous chapter introduced the concept of interdisciplinarity and its usefulness as a tool in environmental analysis and decision making, this chapter builds the conceptual model through which the case-study problem of road transport derived pollutants will be viewed. The role of this chapter is to outline and support the approach taken in this thesis for understanding the linkage between the individual, collective individual behaviour, institutional form and general societal behaviour, and the way these interact with the external biophysical aspects of their environment. It will discuss how this understanding can be used in environmental management to effect change.

Referring back to figure 1.2 (chapter 1), one can see that this framework essentially establishes the centre box position of this diagram and works as a conceptual tool for integrating the social and natural sciences in interdisciplinary research. Reflecting this interdisciplinary approach the framework draws from a diverse literature source including strategic and institutional management studies, cultural theory, anthropology and economic literatures, and some concepts from human ecology (including the role of niche separation and specialisation in the emergence of form). The aim of the chapter is to establish the following working hypotheses. These are clarified in section 2.2.

1. *Social systems are a tiered aggregation of formal (often structural and stated strategy) and informal lower tier institutions (i.e. values and norms, how things are actually done). These are derived from stated or unstated agreements between individuals with the aim of maximising specific attributes of a personal concept of utility within social and environmental*

constraints. The aggregate interaction of these institutions gives rise to emergent social culture.

2. *An institution's structure (what it is) and strategy (what it does or aims to do) are both material manifestations of the institutions from which it is formed and amounts to aspects of its culture.*
3. *An institution places occupational and spatial constraints on its members and therefore produces a situation where its culture can evolve separately to that of the wider environment.*
4. *Non-alignment of an organisation's culture with the wider societal culture and/or biophysical parameters in which it operates can severely impede the ability of that organisation to achieve its stated aims, giving rise to the concept of the strategic gap. The resolution of this gap requires a transformation in the organisation's culture.*

2.2 Towards a Theory of Cultural Change: Individuals, Institutions, Values and Perception.

Since one of the propositions supported in this chapter is that social systems are a series of intermeshing and tiered institutions (North 1994) which co-evolve from collective individual behaviour, the institutions which it forms, and the wider external environment in which they sit (Layder, 1996); then it is with the individual that the framework should begin.

2.2.1 The Individual

It has been proposed that in any society individuals will aim to maximise their personal utility within the constraints of their own perceived rationale (Lin, 1989; see below). The term utility, however, has often been criticised within the terms of the traditional economic definition of the *individual utility function* (see glossary) in that it over-simplifies the motivational aspects of human behaviour (North, 1994). To address this fact the concept of utility is expanded to express a sense of well-being that may include material gain or wealth but also health, prestige, pleasure, and security as well as other non-material considerations (North 1994; Vickers 1984). It is also proposed that an individual may forego maximising one aspect of this utility in favour of another or some configuration of a number of others (Vickers 1984).

The term *rationale* is used here to distinguish this perception from rational and irrational behaviour. It essentially purveys the concept that people (or institutions) will act rationally within the constraints of their ability to receive, store and retrieve information and their ability to communicate this knowledge or perception to others (Williamson, 1975). This concept shows analogy with Blumer's *inner world* concept, established in the Symbolic Interactionist school of social theory which defines it as:

> *"the internal conversation and talking to ourselves that creates an inner world through which we see ourselves and others"* (Blumer, 1969).

This inner world is described as evolving out of social interaction itself, in terms of an individual's past experiences or, as described by Hughes (1937), their life-path which develops within their own personal environment (Blumer, 1969). This leads to the development of a wide range of subjective perspectives, values and knowledge-sets through which people view their immediate environment (Hagerstrand, 1970).

Knowledge which individuals or groups have of social affairs therefore exists within a communal framework which is both fragmented and dispersed across millions of people within a tiered cultural process. Decisions tend to be made on an individual disparate basis and not on a universally accepted explicit centralised knowledge base (Barry, 1988). Decisions and agendas are instead based on a myriad of subjective snippets of tacit knowledge acquired through personal experience and for the facilitation of personal goals (Barry 1988; North 1994).

The proposition here is that we live in a world populated by individuals acting within their own rationales. However, the traditional tendency in economics, planning (the array of transport models available demonstrates this point well) and regional analysis is to treat people as aggregate generic objects. People tend to be treated as *dividuals rather than individuals* (Hagerstrand, 1970), or to put it another way:

> *"The study of society is based on the assumption that everyone is alike and no one is alive"*
>
> (Hugh Kingsmill Lunn, quoted by Holroyd, 1964)

People tend to be assigned stereotypic roles at particular times leading to broad assumptions being made on desires and responses to environmental change. Analysis tends to be carried out in an overly formalistic way (Healey, 1989a).

This is counter to the way in which the world operates. Aggregated human behaviour tends to be extremely complex, and a typical result of this collective complexity is the concept of emergent phenomena These may be organisations, legal systems (a good example is that of tort law), beliefs, patterns of behaviour (Ahuja, 1996), or unforeseen problems of environmental degradation (Hadfield, 1997). These phenomena are spontaneous evolutionary processes. They are the product of human action without any human intent and have been defined in the text as third world phenomena[1] (Barry, 1988). They may be beneficial for the individual or society or miasmatic. They can even give rise to a situation from which many individuals benefit but the wider society loses, and while the individual can see the wider impact of these actions, there is no incentive for them to change their behaviour. This situation has been described as the prisoners' dilemma (Barry, 1988).[2]

So far we have a situation where in this spontaneous and ultimately unpredictable world each individual strives, separately and/or collectively to maximise their personal concept of utility (Lin, 1989) within the constraints of the expectations of themselves, and the perceived expectations of others (Blumer, 1969), and the practical constraints imposed on them by their immediate environment (Vickers, 1984). In order to facilitate this desire people tend to create, either consciously or spontaneously, institutions (Ahuja, 1996 Lin, 1989 Bate, 1994) so as to promote specialisation in one aspect of utility maximisation to give the individuals belonging to these groups a competitive

[1] see glossary

[2] see glossary

advantage over other members within a society (North, 1984)[3]. It has therefore been suggested that the reason why institutions come about either involuntarily or intentionally, is the propensity for humans to trade in goods (North, 1994; Ahuja, 1996). This concept as Vickers (1984) points out, can be extended to include both ideas, traditions and values. They have as an aim to facilitate a sense of group security or from (the sociological literature) facilitating the fulfilment of personal status and self expectation (Becker, 1970).

2.2.2 Institutions

Institutions have been defined as "*the rules of a society that facilitate co-ordination among people by helping them form expectations which each person can reasonably hold true*" (Ahuja, 1996). In this way it can be seen that in a society the main role of any institution is to superimpose a degree of certainty on the essentially chaotic results of collective human behaviour. This view is echoed by Blumer (1969) who describes institutions as "*social structures that while they do not guarantee agreement between different parties within society, do form a basis on which individuals or groups can anticipate each others behaviour*".

Institutions have often been classified within two categories (table 4.1-1) A distinction between these categories that was made by Giddens (1984a) who termed the two types as:

Social systems: such as practices, values and traditions; and

Institutions: such as rules and sets structures.

Table 2-1: Institutions can be formal or informal, spontaneous or created.

	created	**spontaneous**
formal	constitutions government departments legislative law	tort law market systems
informal	fashion	norms values traditions

[3] A useful analogy here can be derived from the population ecology literature on niche specialisation. Indeed a commonly used definition of an ecological niche is "*the role or profession of a group of organisms in the environment, its activities and relationships with the community*". Niche specialisation may spontaneously occur within a ecosystem due to inter-specific competition for limited resources or as a result of predation (Begon and Mortimer 1989). Therefore conversely an institution can be seen as a tool for niche realisation of a group of individuals within a human community offering the individual the reward of specialisation in one aspect of utility but affording costs in the form of a restriction of range open to the generalist (North, 1994).

However, as Layder (1996) points out this terminology tends to imply a discrete difference in the root concept of the two phenomena and a more accurate definition of these structures lies in the terms *informal* and *formal* institutions. This is the same definition found in much of the management literature (e.g. Bate, 1994; North, 1994), and is the one that will be used in this thesis.

Informal institutions such as traditions, customs, and ethical and moral norms, are implicit within society whereas the formal institutions tend to be explicit (North, 1984). The latter include such phenomena as constitutions, governments and corporations (Ahuja, 1996). These explicit institutions are more tangible than the implicit institutions, they are more the players of the game than just the rules and assumptions by which the game is played (North, 1994). Thus for the sake of clarity the corporations, political bodies and other identified bodies of people working within set goals will be referred to as organisations and this term is used only to refer to this one specialised sub-group of institution.

At this point it should be noted, that the hard distinction between the formal and informal institution, common to the economic texts, is rather simplistic since the boundary between the two is not discrete and implicit institutional constraints may well influence the nature of explicit institutions and visa-versa (Bate, 1994). This influence may be mutually reinforcing, competitive, or a mixture of the two (Lin, 1989). The essential feature of the two is, however, the same. Institutions are both the *"medium and outcome of collective individual action and motivation"* (Giddens, 1984a). They are formed by individual beliefs, value sets and agendas and like these, they evolve (North, 1994). They are there to help maximise an individuals' propensity to trade by allowing specialisation and some degree of predictability over the world with which the individual trades (Viessman, 1988; Lin, 1989; North, 1994; Ahuja, 1996). In this way institutions can be seen as:

> *"a set of constraints on behaviour in the form of rules or regulations, a set of procedures to detect deviations from the rules and regulations, and finally a set of behavioural norms which define the contours that constrain the way in which the rules and regulations are specified and enforcement is carried out"*
>
> *(North, 1984)*

A central concept to these definitions of institutions is that they are something more than has often been conventionally considered.[4] They also embody cultural norms, beliefs, traditions and ideology (North, 1984). Indeed the definition of ideology as a ubiquitous set of beliefs contracted by individuals to facilitate the rationalisation of the world around us (Lin, 1989) sounds very similar to that of the definition of institution

[4] For example the Oxford English dictionary describes an institution as a society or organisation set up for the promotion of scientific, educational or other public objective.

(see above). They recognise also the more spontaneous aspects of human collectivism. Therefore it can be seen that rather than strategy and institutions being the discrete entities that they are often thought to be , they are linked to the point that one may reasonably conclude that they are synonymous (Bate, 1994). If this is the case then it can be postulated that institutional change implicates strategic change and vice-versa.

At this point we have an image of an institution as a collection of individuals who for some purpose have chosen to abide by collective constraints (concerning their goals or actions) in order to maximise group gain and within that, individual gain in a specialised area. This acceptance of individual constraints however, recognises an element of cost to the individual on their freedom to maximise other aspects of their life (Ahuja, 1996). Since individuals are essentially driven by self interest (Vickers, 1958; Barry 1988; Bate 1994) they will only belong to a given institution by either recognising some kind of personal gain, or by force or coercion (avoiding personal loss). This feature is phrased slightly differently in Giddens' *Structuration Theory* which points out that "institutions only exist insofar as they are bound up with people's motivations" (Giddens, 1984a). If this benefit is seen to be relevant to the individual they endorse their value by using them and therefore perpetuate them (Giddens, 1976).

Here we can have a conflict between the wish for individual maximisation and group maximisation. There may be numerous occasions that arise when an individual can benefit by maximising personal utility by behaving beyond the constraints of an institutional agreement. If this occurs collectively it may threaten that institution, a situation which may arise even if the individuals think these rules or norms are important for everyone else to follow (North 1984; Acury and Christianson, 1992; North 1994). Within any institution, be it a small company or national society, dissension can and does occur. This is noted by Giddens (in (Layder, 1996) when he states that:

> *"People are not compelled like atoms, by external forces outside themselves. They do not act mechanically, but are always capable of resisting constraints imposed on them by society and of influencing and transforming their social situation."*

Furthermore, it can be very costly to assess whether the individual is working within the agreed constraints of that institution (Ahuja, 1996). A cost that, if it needs to be borne, can make policy options counter-productive or impractical (North 1984; Lin, 1989; Ahuja, 1996). This is the case for the following reasons:

a) It is often difficult and costly to detect dissension;

b) It is costly to measure what constitutes dissension; and it is therefore often beneficial for one party to argue convincingly that no breach of agreement has occurred; and

c) policing is imperfect since enforcement officials are agents of institutions but do not reflect the perfect image of institutional constraints. They are not immune to the ideological and utility functions that drive the self/institution conflict which they are meant to oversee. Or to put it another way "*Quis custodiet ipsos custodes*" (Juvenal 347). If enforcement officials deem the contractual arrangements unfair within their own personal construct they may well find in favour of one party by either refusing to confirm a breach of contract or by imposing costs on the offender way below those needed for any form of deterrent (North 1984). This particular phenomenon has been prevalent in environmental litigation (reviewed in chapter 4.3).

From this position it can be seen that the alignment of ideologies or value sets (i.e. the informal institutions) between the individual and any organisation can vitally affect the cost of implementation of a contract and any gains derived from it. If the value sets of the people at whose behaviour the policy is aimed are greatly out of step the more likely it is that the policy will run into problems with acceptance (North, 1984). However, to date development of a framework within which we can understand and account for these informal institutional arrangements within which contracts (be they policies, laws or financial agreements) sit, remains one of the major neglected subject within policy analysis (Ahuja, 1996).

2.2.3 Ideology; Values & Perceptions

> *"It is argued that the policy makers in the past have ignored the role of local values, ethics and ideologies in the design of environmental policy: these factors can severely affect the policy outcomes and thus need to be integrated more fully in the policy making process"*
>
> *(Vinod Ahuja: World Bank 1996)*

This last point leads us again to the role of ideology, personal beliefs and opinions. These have been described as the windows through which each individual views the world (Hagerstrand, 1970). They are formed from, and form the experiences one encounters within one's immediate environment (Becker, 1970; Giddens, 1976; North, 1994). This interaction forms the way one draws meaning from the world (Becker, 1970), or what is often termed as one's perception (Madu and Jacob, 1991). Therefore, ideology, values and perception can be considered as intrinsically linked (Cohen and Levinthal, 1990) an expression of, as well as a formative characteristic of, an individual's life history (Blumer, 1969).

In a spatially compact society with amalgamated economic activities such as those of small-scale agricultural societies, experiences of each member of the society tend to overlap. This situation gives rise to a compatible and closely aligned set of values and ideologies and therefore there is much room for consensus formation (North 1984). However, as a society becomes more spatially disparate, and the economic activities within that society become more varied, then the activities and experiences of individuals become more varied (North 1994). To put it another way there is a wide variation in the individual life-paths or collective life-paths within the society (Habermas, 1987). This leads to a situation where any institution represents a collective of individuals who have a range of varying and often conflicting ideologies and consensus becomes impractical. This distancing is greater as one moves up the hierarchy of institutions from, say, community to nation (Habermas, 1987), and the emphasis shifts from finding a common consensus to one of managing and resolving conflict (Hofstede, 1994).

Leading on from this proposition we can detect from the literature concerning cultural anthropology, three variables concerning culture and its associated values and perceptions (North 1984; Ahuja, 1996, Hofstede, 1994). The first of these is the *spatial aspect.* Since we have proposed that people's *inner world* develops through interaction with their immediate environment then we can surmise that perceptions change depending on spatial distance, due to the changing nature of a person's environment. This leads to the evolution of different perceptions and customs as people are faced with different problems resulting from different geographical surroundings.

The second is an *occupational distinction*; perceptions vary in relation to an increase in the variety of activities individuals undertake as each pursues separate interests and activities leading to different values and cultures surrounding different professions (Vickers, 1984; Bate, 1994). Also, within the same occupation, consensus in ideology and perception becomes less viable as the occupation grows and there is less personal exchange and communication between parts or tiers of that organisation.

A third factor *time* comes about through the evolution of life paths (see section 2.1.1) both individually and collectively (Hughes, 1937). Each individual aiming to maximise their personal utility within the constraints of their rationale (itself a function of ideology and their spatial and occupational environment) traces a life path of action and knowledge (or experience) requisition. In this way, as their environment (physical and occupational) and thus their experiences change so does their ideology and hence perceptions of issues (Hägerstrand, 1970). This leads to a pathway of perception and ideology that evolves throughout an individual's life (Blumer, 1969), under the constraints imposed by the institutions and biophysical environment around him or her, and the perception of these constraints (North 1994). The changing nature of both the environment and its perception by the individual may lead to an individual exploring or developing their perception in such a way as to maximise a particular concept of their personal utility (Jeffrey and Lemon 1996) thus changing their experiences, and hence ideologies (Figure 2-1).

The cumulative effect of these features is a spontaneous development of cultural pathways (Bate, 1994) which may diverge from the individuals original values, ideologies and perceptions in a way at the micro level that is unique to each individual and may result in a divergence of values from those proposed by other individuals or institutional values held within a society. A method of reducing the impact of this increasing physical, social and occupational distancing between institutions and the individuals they are intended to represent, is the creation of the sub-institutions and the tiering of the institutional framework. This can be seen in both formal institutions such as government (local government, national government etc.), corporate structures, and informal structures such as customs and traditions (local culture to national).

Like all institutions these subsidiary institutions may be designed or spontaneous in their genesis but tend to develop a dynamic of their own. They consist of a group of individuals who by form a specialist collective with the aim to increase their personal utility within the confines of that institution, leading to a sub-grouping of experiences, values and norms within the higher tier societal institutions, i.e. the development of a sub-culture (Bate 1994). These may diverge from higher tier or lower tier cultures due to increased specialisation, both occupationally or geographically over time in much the same way as described above (see 2.1.2).

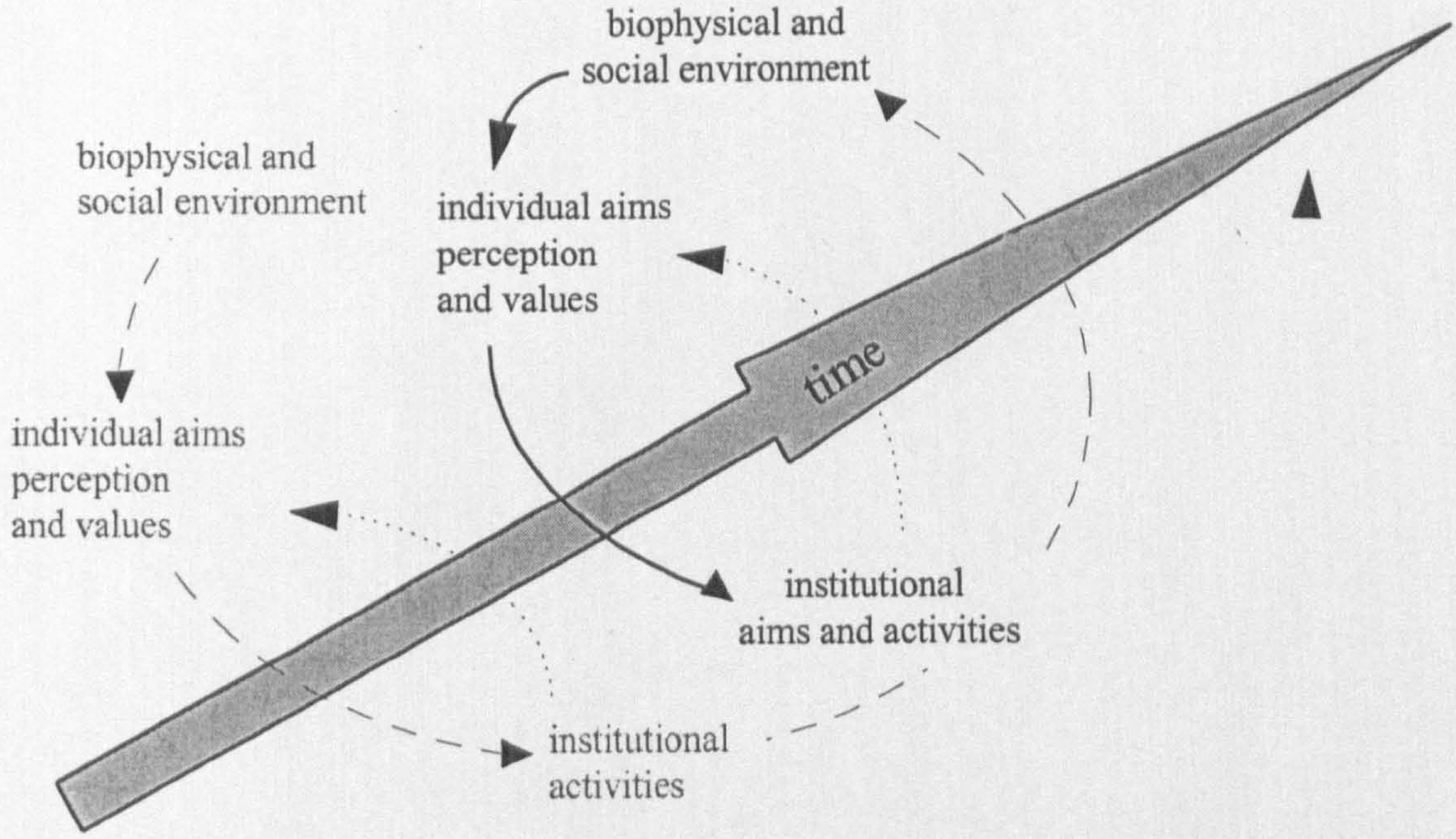

Figure 2-1 individual, institutional and environmental co-evolution

However, it is often recognised that due to the rather rigid statutory status of many of these institutions, especially bureaucratic organisations (Morand, 1995), some of these institutional forms present in a society may often become less responsive to change than the population they aim to represent or work within (North 1984), or the environmental uncertainties they are meant to deal with (see 4.1.2). This feature essentially comes into play when the efforts of an organisation's culture becomes more focused on maintaining the internal structure of the organisation, rather than relating to their external environment (Harrison, 1989). This can lead to problems of time-lag between issues facing a society and the mechanisms through which a society aims to manage them. This process over time may lead to a situation where the institutional form becomes distant to that needed for the institution to realise its ambitions or aims. This situation results in what has been termed the *strategic gap*[5] (Harrison, 1989), where the institution may need to change its culture (Bate, 1994) or lose legitimacy in representing individual motivation.

2.2.4 Change

> *"There is a growing awareness that the problems and mechanisms of managing strategic change in organizations needs to be explained and considered, not so much in terms of traditional rational planning models of strategic management, but in terms of the cognitive, cultural and political context of*

[5] see glossary

> *constraints in organizations and the managerial action which addresses these."*
>
> *(Johnson 1990)*

Previously it was proposed that the traditional distinction between an organisation's structure and strategy was artificial and that all of these aspects are emanations of the organisation as an holistic whole or culture. This section will explore the implications of this concept for approaches to the identification of form, need and approaches to strategic change.

Since the aim of an institution is to impose some sort of stability on what is essentially a chaotic world, to allow for individuals to maximise their ability to take from their immediate environment while providing a degree of insurance over the uncertainties of operating in that environment (see 2.1.1), the role of institutions can be seen to be two-fold, to allow the individual security and the opportunity to pursue personal utility (Vickers, 1958). These personal wishes are translated into institutional aims. Individuals/institutions and cultures form a tiered hierarchy with each level forming a net of interacting sub-systems (Vickers 1958). These are open systems dependent on the interactions within these networks, the biophysical environment within which they sit and the wider social system in which they operate. None of these features are static and it is the interaction of these formal and informal systems that within any organisation results in a continuous reconstruction of what the organisation is (Morand, 1995). Both the societal and managerial systems are essentially constrained by the biophysical features in which they operate and the tighter these constraints are the less room there is for social environmental and organisational management (Starik, 1995).

Therefore when one considers whether strategic (or cultural) change is necessary one must look to how an institution balances its needs between internal stabilisation (its formal and informal sub-systems) and external functionality, one needs to remember that change is occurring and is implicit to an organisation. The question shifts from *"is change needed?"* to *"do we need to manage change, if so can we and how?"* (Bate, 1994).

2.2.5 Cultural Development and Cultural Transition

Given that change in any institution's culture is implicit, the reasons why one would want to manage it lie in the need for an organisation to improve or maintain its performance within the constraints set by its external environment, or to change what is essentially a destructive code of conduct in order to either achieve its aims within acceptable boundaries or, at the extreme, to survive (Harrison, 1989).

This would imply that there are two distinct types of change:

1. adaptive change when an organisation finds its general progress satisfactory and wants to optimise its performance, then it can choose to carry-on with its activities and adapt these (either consciously of not) to the changing social and natural environments. This has been described as *cultural transition* (Bate 1994). The shape of the strategy may change but not the its underlying properties (i.e. in transport management this could be seen as a shift from the approach of a regulatory predict-

and-supply approach to one of restricting usage by restricting supply, or some other top-down method of controlling demand).

2. Radical change is the second option for changing and institutions culture. This approach is required when the prevailing cultural approach of an organisation is failing (Bate, 1994). The organisation can no longer satisfactorily achieve its aims and has either become incongruent with the social and/or natural environment in which it sits, or the internal formal and informal institutions that hold the organisation together are breaking down (often both situations occur at the same time). This situation requires a replacement of the culture of the organisation or a *cultural transformation* (Bate, 1994), if an organisation is to achieve its aims.

It can be seen that the design of strategic programmes needs to consider much more than the co-ordination of mechanisms. The process carried out with any affect needs to consists of two distinct stages. The first step is to assess whether the organisation needs to undergo a process of cultural transition or transformation (Bate, 1994). This is essentially a question of whether the present culture is capable of achieving the organisation's stated aims or if there is a problem of a large strategic gap or institutional incongruity, needing a cultural transition (Harrison, 1989).

It can be seen, therefore, that the ability of an institution's structure and strategy to be able to recognise and communicate with the array of values and norms within the social environment can be crucial to the success of that institution or any of its associated policies and programmes (Hutton and Ahtola, 1991; Ahuja, 1996). This also seems to be the point that is being raised by Nonaka (1988) in the call for a bottom-up process for inductive learning in organisations. Strategies that deviate from these norms may face the problem of inapplicability and resistance (O'Riordon, 1996).

A second and related point is that of the need to align strategy and structure with biophysical constraints. This is especially true when the organisation is dependent on the state of natural resources to realise its aims, and is therefore is crucial in the field of environmental management. Policies and programmes must not only take account of symptomatic results of degradation for the issue they are approaching but must also be devised so that they take into account the constraints and relationships presented by the natural environmental systems for which they are concerned (Committee for the National Institute for the Environment Proposal, 1994; Hadfield and Cannibal 1996; O'Riordon, 1994). These are often poorly understood by policy makers and indeed by the scientific community as well (Committee for the National Institute for the Environment Proposal, 1994). However, at present many approaches to policy analysis seem to pay little regard this fact (Glasson, 1992).

It will be shown that biophysical systems, like social systems, can change at different spatial and temporal levels where linked processes may materialise as different phenomena at different locations while the source may be distant, or regional, or a mixture of the two (Chameides, 1993; see chapter 6). These systems, like social systems, are spontaneously dynamic and may form complex emergent problems (Furguson, 1776; Barry, 1988). Institutions need information-flows that can facilitate a complete understanding of the underlying processes which give rise to these phenomena. Without them, it will be demonstrated, the result may be that strategies approach the wrong problem at the wrong level (Hadfield and Cannibal 1996).

As well as a methods for understanding the complex linkages present within an institution's external social and biophysical environment, the institution must recognise how its own internal environment can constrain its options in achieving its aims (Harrison, 1989; Bate, 1994). Therefore, another diagnostic feature needed when designing programmes for cultural change is to explore the culture that needs to change, to identify the parts of that culture that are beneficial and those that are miasmic, and to identify the vicious and beneficial circles (positive feedbacks) implicit within the organisational culture (Bate 1994). These can result from the often base assumptions made by key players in the institutions or assumptions that have become part of the institutional culture as a whole.

These feedbacks are evolutionary processes resulting from past influences, decisions and constraints. They form the skeleton and much of the flesh of the culture in which modern actions are based both on a structural (and thus strategic) level as well as the informal level of belief and ideology (Sperling, 1984). They can constrain both the practical choices of the present manager and their future options, but just as importantly may constrain the perception of what is possible (viz. the option space) of present and future management (Coggins, 1996). When exploring any environmental management strategy one must not only look at the social and biophysical aspects of the phenomena in question but also the nature of the management system itself.

2.3 Summary and Conclusions

It has been argued that in an institution, what are often termed institutional strategies and structures, are in fact implicit sub-components of that institution's culture (Bate 1994), which in turn is with many other institutions part of a wider culture, within which individuals sit. This wider culture forms individual life experiences and therefore rationales, the agglomeration of which feeds back into the institutional cultures (Giddens, 1991). They can be described as a tiered hierarchy of interlinked sub-systems within a social/biophysical macro-system or what Pablo and de Agar et al. (1994) describe as the socio/physical complex. These systems are open systems integrally linked, and it is these linkages that create their dynamic qualities (Checkland, 1981; Vickers 1958).

Within this system each individual strives to maximise a concept of personal utility or well-being and the main constraint an individual faces in this aim to maximise is the ability to know all things at all times. Instead each sees the world within the context of their rationale (section 4.1.1). Institutions can be seen as tools to modify the scope of this rationale for perceived gain, be it economic, non-material pleasure, or security. Institutions within a society, formal or informal, are the result of collective individual actions aimed to facilitate the maximisation of specific aspects of their personal utility by collective specialisation. In this way institutions are an implicit product of human collective behaviour rather than something distinct from it (section 4.1.2). They embody collective norms, values, perceptions and aims and in doing so they form the both the implicit and explicit structure of a society (Giddens, 1984b).

Institutions however, are not purely a bottom-up aggregation of human behaviour, since membership to an institution places the individual within a different occupational and spatial context compared to other members of the society as a whole, or what amounts to a sub-culture. Their experiences become aligned to that common to that institution and it is these experiences that form their rationale over time. In this way an institution can develop a collective rationale of its own (section 2.1.3). The development of this rationale therefore occurs both at an individualistic level and an institutional, in response to the wider environment in which that institution operates in. Since individuals in society associate themselves with a great many institutions for different reasons: it is often the case that there is a great diversity in value-sets occurring in society as individuals develop their experiences and rationales by interaction with the wider social and biophysical environment as well as with other sub-cultures (or institutions). This diversity also is apparent within any specific institution

Furthermore, when one talks about cultural change one must remember that change is implicit to the character of any institution (or culture) and while some institutions are designed with specific intentions (aims) in mind they are all essentially spontaneous in nature and are the result of collective emergent behaviour. This may be conducive to the explicit aims or not, and in the latter case may give rise to sets of values that, while having been previously successful for the achievement of explicit aims, have since become obsolete but at the same time become institutionalised as values of members (often top managers or other long standing members of the institution) within the organisation as a whole.

For any institution to survive, it must be able to relate its usefulness to individuals in terms of supplying more perceived benefits than costs to its members. This usefulness may be explicit i.e. a stated aim, or implicit - a feeling of belonging, depending on the institution. However, in either case it depends on two factors:

a) the ability to maintain its internal structure, and

b) the ability of the institution to relate to the wider environment (both social and biophysical) within which it sits and achieves it aims within acceptable limits (Vickers 1958).

Each institution, therefore, like every individual, needs to balance its needs and opportunities to survive for any period of time, either in its original or modified form. A state that has been held as a prerequisite for a sustainable process (Harrison, 1989, Starik and Rands, 1995).

Its should be noted at this point that these two dynamics affecting any institution are interlinked since all institutions are sub-sets within the wider social environment and also the individual members of institutions are members of the social environment. They are influenced by it as they are influenced by the institutional sub-culture. Rationales and cultures internal to the institutions are also a part of the wider culture they may influence that culture directly or indirectly and can be influenced by it. Institutions (including organisations) are not distinct from their environment but are properties of that system when viewed at a particular spatial or temporal or occupational resolution.

The next chapter will identify many of the contemporary problems facing environmental management by using the case study of transport-derived tropospheric ozone. It will illustrate how this, like many other modern issues, is a problem with many complex social and biophysical features which exist in an atmosphere of scientific uncertainty and is surrounded by many conflicting values and needs. The chapter will conclude by applying the theoretical framework of the environment as a socio-biophysical complex to the problem of managing air pollution. It will argue that once we recògnise these dimensions apparent in the problem, these features make the management of this pollutant particularly problematic, and encompass a whole range of issues that can be classified as social, political and technical, requiring an integration of approaches from what have been traditionally very discrete professions (Knowles, 1971; Friend and Jessop, 1977).

However, historically the management of air quality in this country has evolved to deal with problems of a more local nature, centred around single issues. This has lead to a present system of specialisation and therefore reduction (both professionally and geographically) in approaches to environmental and social management. The result is that present approaches to air quality management exist within a segregated disparate local and national framework designed around a divided departmental structure (reviewed in chapter 4). Each of these departments have to some extent operated in what can be described as isolation, normally operating in a high degree of isolation (Smellie, 1969). It will be argued that if one is to successfully deal with the influences that the social and biophysical sub-components of this issue have on each other, one must examine these features and apply a management structure that can account for the different issues pertinent to these features at different levels of resolution as well as how these features interact with each other as well as the management system itself.

This will require a distinct shift in the present culture surrounding air quality management in the UK.

3. Tropospheric Ozone as a Biophysical and Social Problem.

This chapter will introduce the management problem on which the thesis will focus, namely the management of traffic derived tropospheric ozone. This pollutant provides special problems for environmental managers in that the production of the pollutant is distant from the reception, both spatially and qualitatively. Furthermore the emission of the substance is not discrete and results not from a single point process, but from the common and legitimate activity of using the private motor car. In addition to these problems the production and transportation rates of this pollutant show distinct temporal and spatial variation, with a number of paradoxical issues being generated in different places at different times.

The effects of this pollutant are embedded in scientific uncertainty. The issue varies depending on the scale and over which time period it is viewed, and on how and by who the issue is perceived. Therefore a further problem arises when one considers the questions surrounding the definition of the impacts which the recipient population is subjected to.

The final section of this chapter positions the problem within the theoretical framework of the environment as a complex evolving social and biophysical process showing qualitative and quantitative change at different levels of resolution. It reviews the implication of this perspective for management and describes how these issues will be illustrated through research activities in the second part of this thesis.

> *"Of all air pollution problems (...), ozone is acknowledged as the most complex and controversial. Unfortunately, the reasons why the ozone problem still exists are unclear."* (Huess & Wolffe, 1993).

3.1 Introduction.

The history of air quality management in the UK is both long and complex, reflecting a series of past issues concerning different pollutants, with different causes and effects. Throughout the development of our modern society the main concern of air quality policy has been to balance the interests of industry against those of human health (Ashby and Anderson, 1981). This has produced a framework of national, regional and local institutional bodies, all with their own structures and functions (these are described in-depth in the following two chapters), which are oriented to past problems but are often ill suited to the new and emerging issues at hand (Veissman, 1988).

This thesis considers the problem of managing tropospheric ozone in the south central area of the United Kingdom as an example of a dispersed synergistic pollutant that is essentially the result of human behaviour (i.e. the common usage of the motor car) but without any human intent. This essentially spontaneous result of an activity produces a damaging outcome for society at large but it is beneficial for the individual and can therefore be seen to be a classic example of the prisoners dilemma[1].

The following chapter introduces the systemic nature of this pollutant, from source through its transport and transformation to its reception and the impacts (both perceived and physiological) it may produce on the recipient population.

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[1] see glossary

3.2 Ozone and its Precursors.

Within the international community much attention has been given to the problem of declining stratospheric ozone and its associated health effects, such as an increase in the incidents of skin cancer (DoE, 1994). However, in the United Kingdom, the environmental effects of tropospheric ozone may be of greater importance (PORG, 1993) where the increases in the ambiemt concentration of this gas has been linked to health problems such as asthma (Walters, 1994), and economic problems such as crop yield loss (Chameides, 1993).

Tropospheric ozone is a naturally occurring trace gas produced from the photolysis of nitrous oxide (NOx) in the form of nitrogen dioxide (NO_2) and nitric oxide (NO) in the presence of atmospheric oxygen (see figure 3.1). Background levels of this substance, produced by natural pathways, are fairly high (around 20- 30 ppbv)[2] and it is thought that only two to three times this concentration may elicit significant physical damage in human lung tissue as well as cause yield loss in crops (PORG, 1993).

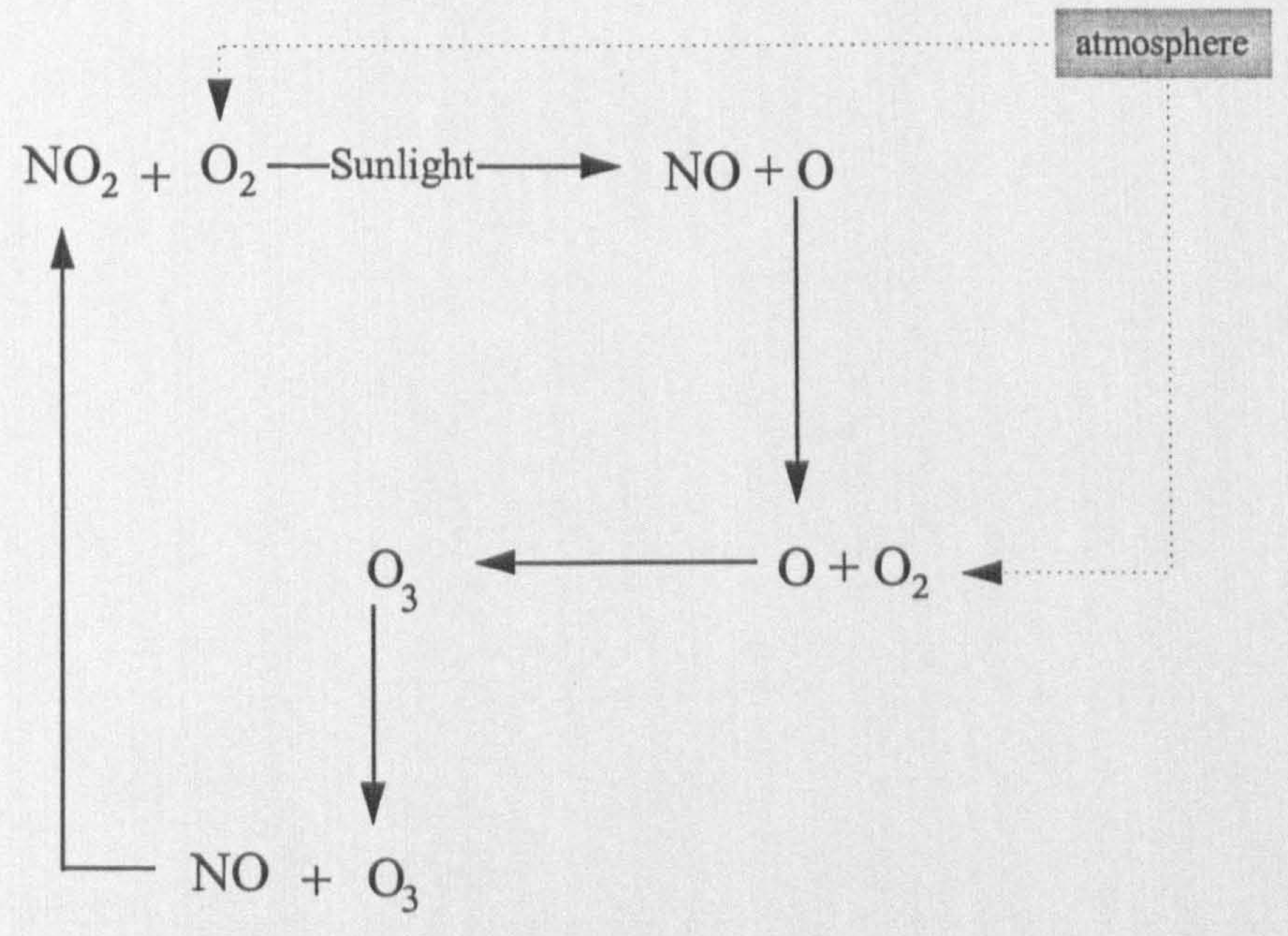

Figure 3-1: The photolysis of Nitrogen Dioxide

However, the entrance of tropospheric ozone on to the stage of problem pollutants is mainly the result of human action and whilst attempts to manage it have been made in some areas of the world since the 1950s, it remains one of the greatest issues facing modern environmental managers today (Huess and Wolffe 1993; Longhurst et al, 1996).

Although there are very few direct anthropogenic emissions of this gas, it is produced as a by-product of the interaction of two main precursors NOx and the non-methane

[2] parts per billion by volume

volatile organic compounds (NMVOCs) which, while found naturally in the environment, are produced anthropogenically in significant amounts by the burning of fossil fuels and other industrial sources. The product and rate of reaction between these precursors is also influenced by climatic factors such as sunlight and wind conditions, all of which show variation over temporal and spatial scales (see figure 3.2).

While the actual chemistry of tropospheric ozone is poorly understood, the nature of these precursors has been studied in depth (McKendry 1992; Chameides, 1993; Huess and Wolffe, 1993; PORG, 1993; Sweeny, 1993; Bower, Stevenson et al. 1994; Chameides 1994; DoE 1994; Gertler and Pierson, 1994).

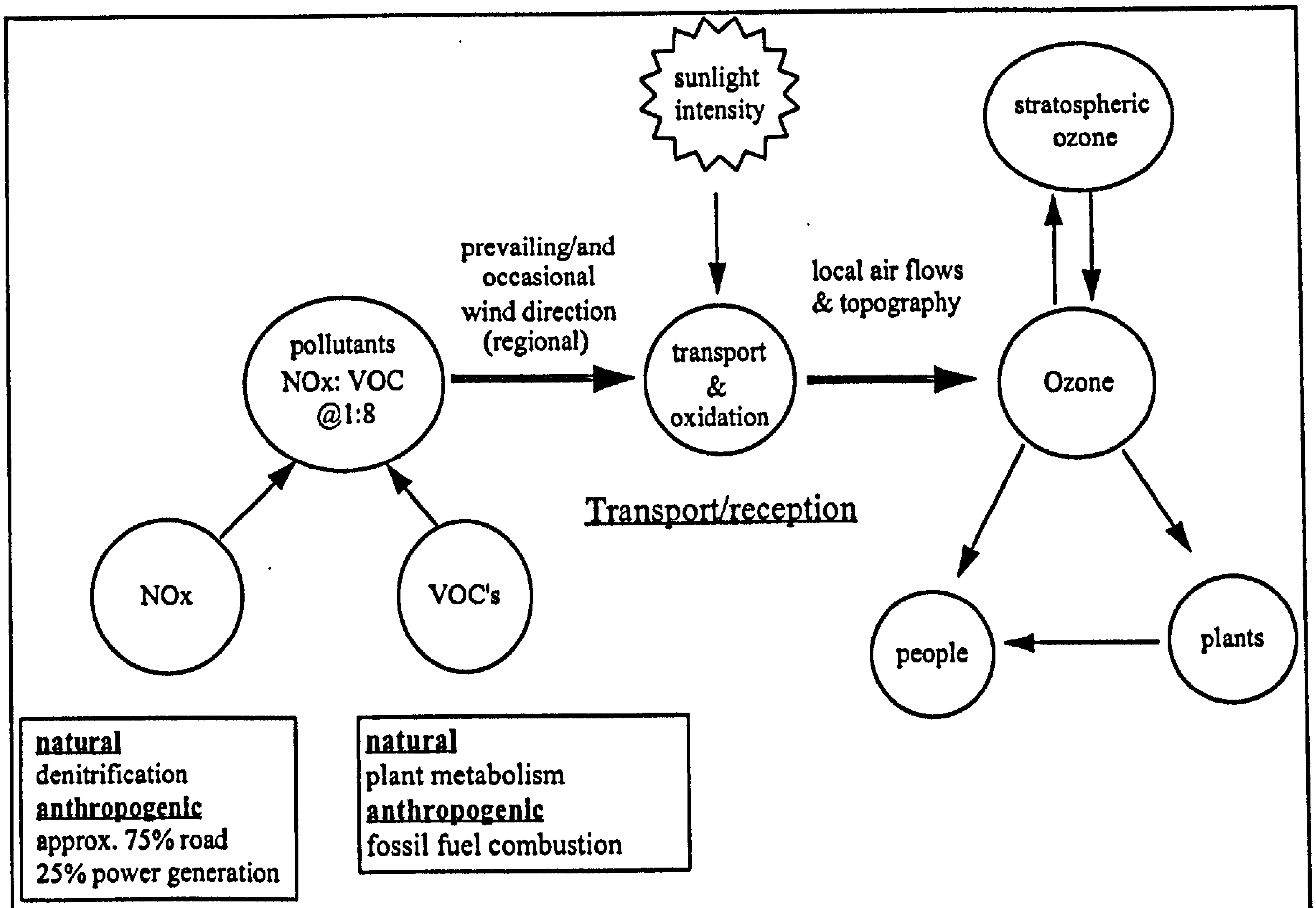

Figure 3-2: Precursors and Climatic Factors Involved in Ozone Production

3.2.1 Nitrogen Oxides (NO_x)

NOx is a generic term given to nitrogen oxides and is essentially composed of nitrogen oxide (about 90%) and nitrogen dioxide (about 10%), although this varies (Badr, 1993). In the absence of anthropogenic emissions NOx is present in the atmosphere at very low concentrations (resulting from microbial activity, natural fires and the action of lightning on atmospheric nitrogen (Guderian, 1985). At these concentrations it forms a vital link in the nitrogen cycle.

NOx is also produced as a significant by-product of human activity and has been implicated in the formation of acid precipitation and human respiratory disease. It is also a main precursor of tropospheric ozone (Badr and Probert, 1993).

In the UK, NOx is a significant product of electricity generation and road transport usage at about 25% and 75% respectively (figure 3.3). However, this ratio changes on a regional basis and the contribution of road transport to NOx emissions is much greater than this in the south (DoE, 1997).

At present there are set guidelines and permissible levels for NOx, under the UK Air Quality Strategy (see chapter 5). However, it is recognised that the guidelines for this pollutant are often exceeded in densely populated urban areas, especially in the winter months (QUARG, 1993). While control strategies, such as the catalytic converter attached to the tail pipe of motor vehicles, are expected to reduce emission of this pollutant in the near future, the success of these may be open to doubt (Air Health Strategy 1996; Air Health Strategy 1996; Air Health Strategy 1997, see chapter 8.2). In any event most models predict a long term rise in emissions of this pollutant (OECD, 1993; DoE 1996) due to the rapid increase in road transport.

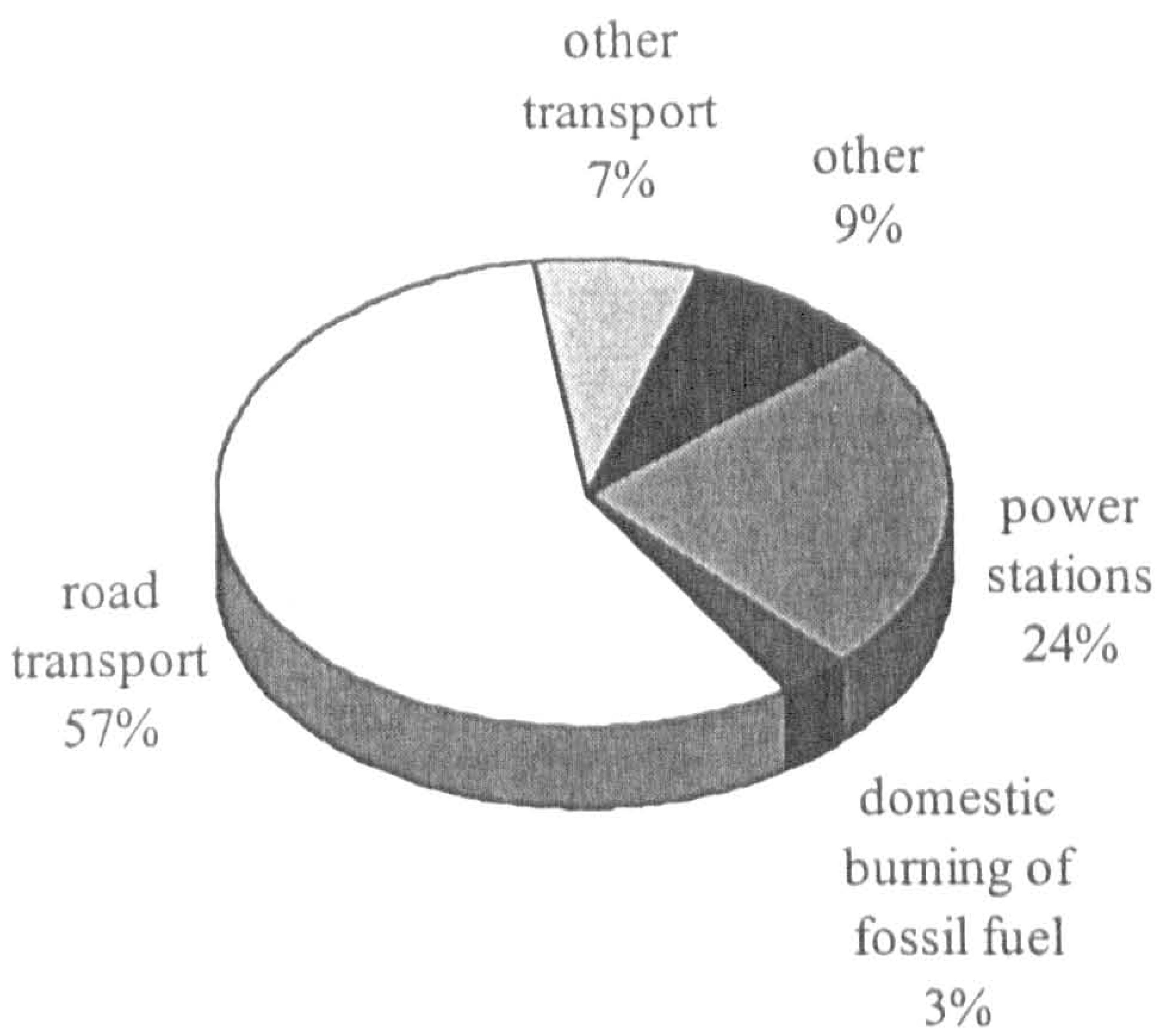

Figure 3-3: NO_x production by sector
(after www//http.netcen.cmem.htp 1996)

3.2.2 The Non- Methane Volatile Organic Compounds (NMVOC)

NMVOC is the collective term given to a wide range of organic compounds, most of which are aromatic hydrocarbons which, while often treated generically in pollution studies, do in actuality represent a wide range of compounds with differing reactivities and therefore transport rates. They are produced naturally as a product of photosynthesis and as the result of organic deposition (Chameides, 1994)[3]. However, when one is concerned with photochemical oxidant production it is thought that the natural emission load into the atmosphere is negligible compared to the anthropogenic production of NMVOCs (Guderian, 1985) through both industrial processes such as solvent use and production (about 40%) and as a by product of fossil fuel combustion (about 45%).

[3] This significance of natural emissions is much debated and is based on work carried out in the USA where vegetation, especially tree, coverage is greater and therefore potential of much greater importance in VOC production. (Chameides 1994)

The NMVOCs come from a wide range of sources (see figure 3.4) and while, like NOx, there are distinct seasonal and diurnal variations in the emission rates of these compounds, the multiple source nature and the long life times of these products, leads to the concentration of these substances in the air being fairly stable (Chamiedes, 1994).

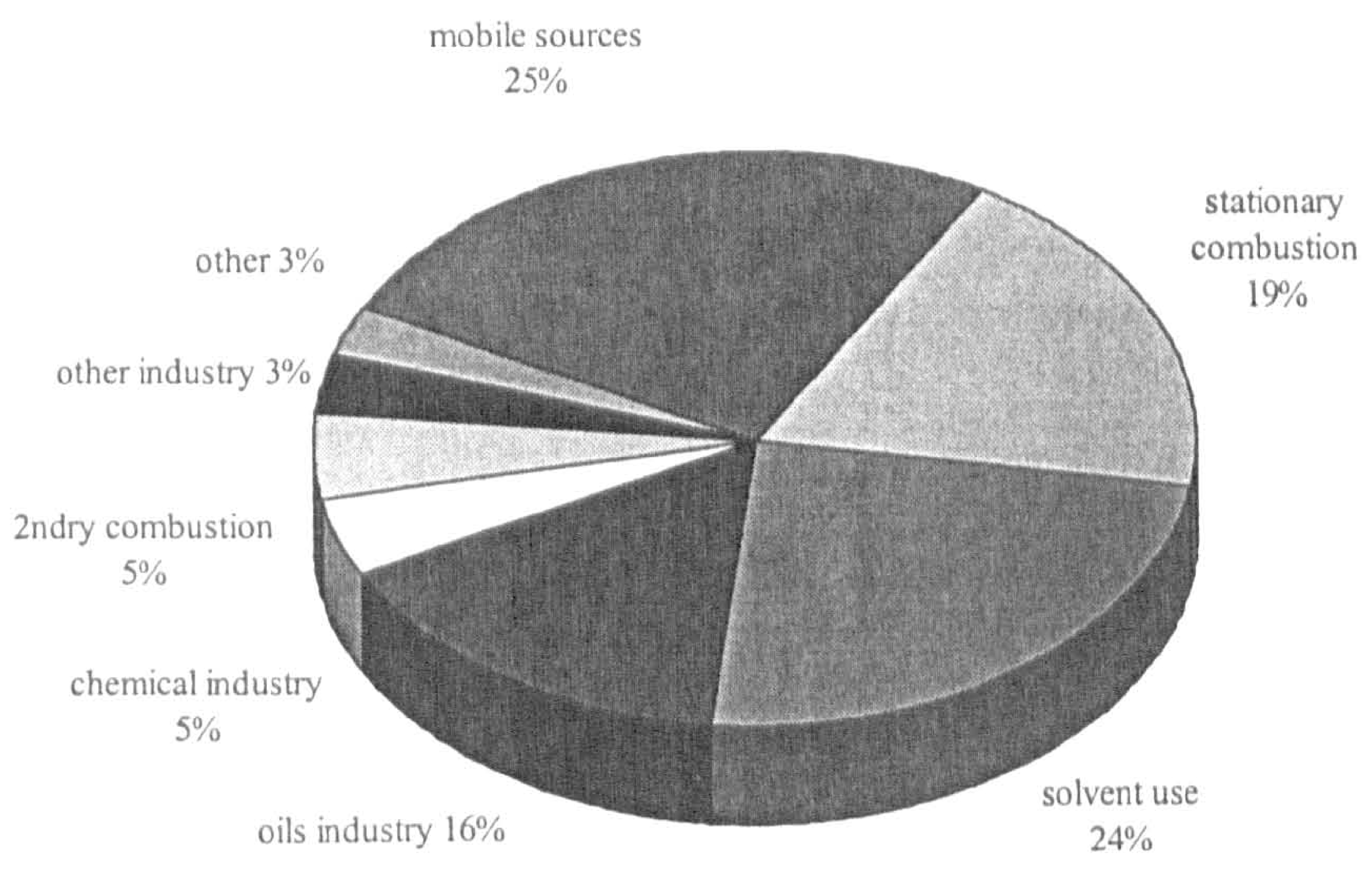

Figure 3-4: The varied sources of NMVOCs (after DoE, 1996)

Although NMVOCs are limited under the United Nation's VOC protocol, there are at present no set standards for the control of NMVOCs as a group in the UK[4], and while legislation on these substances is expected in the near future, there is at present delay caused by the debate between environmental and industrial interest groups which has percolated into central government (Air Health Strategy 1996).

3.3 The Relationship Between Ozone and its Precursors

The chemistry of O_3 formation in the lower atmosphere is extremely complex and poorly understood, involving various non-linear interactions between a whole range of organic compounds with different emission rates, lifetimes, and transport rates in the presence of meteorological (and possibly chemical) catalysts (PORG, 1993). However, the basic mechanics of O_3 formation are understood, as is the dual role that NOx's plays.

In the absence of volatile organic compounds, tropospheric ozone is formed from the photolysis of atmospheric nitrogen dioxide (figure 3.1). In this reaction NO_2 splits in the presence of sunlight, to produce nitric oxide (NO) and a free oxygen radical, which then combines with atmospheric oxygen (O_2) to form O_3. The O_3 freely reacts with NO to produce O_2 and NO_2 thus creating a photostationary equilibrium (DoE

[4] There are set limits on Benzene and 1,3, Butadiene on the basis of the carcinogenic and toxic nature of these substances as individual compounds.

1994); thereby regulating ozone formation. However in the presence of the NMVOCs and their derivative radicals (RO_2), the nitric oxide is extracted from the system to produce NO_2 and the highly reactive NMVOC radical RO, effectively decreasing the level of NO available for the degradation of ozone which accumulates in the atmosphere (see figure 3.5).

A final stage in this equation is the reaction of RO with atmospheric NO_2 (Huess and Wolffe 1993) to form stable products. The effect of this stage in the reaction is the removal from the atmosphere of NO_2 that is open to photolysis and thus ozone formations are curtailed.

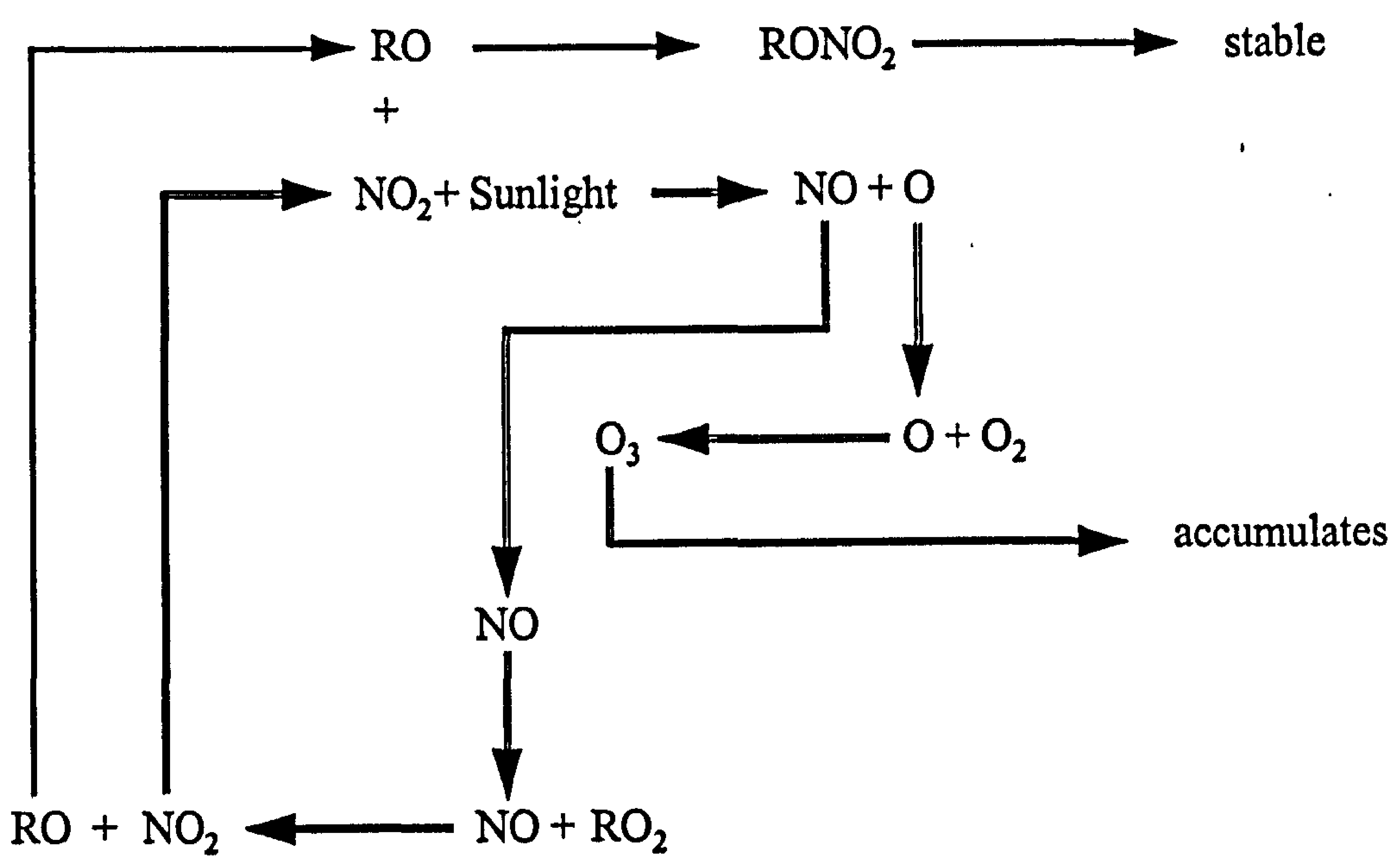

Figure 3-5: Tthe dual role of NOx

The optimum ratio of NMVOC:NO_x for O_3 formation is about 8:1 (Chameides, 1994) to 10:1 (Huess and Wolffe, 1993). However, the relationship between precursor concentration and O_3 production is non-linear and is shown in Figure 3.6. At ratios of less than 10:1 (i.e. there are relatively high levels of NO_x) NO is partially removed from the system but is still present in quantities sufficient to affect O_3 deposition. NMVOC concentration is not high enough to affect the total removal of NO_2 and therefore, photolysis still occurs. In this situation, since the principal component of NO_x is NO, reduction in NO_x emissions results in an overall effect of removing NO available for O_3 deposition at a greater rate than NO_2. NO_x reduction strategies may well result in O_3 production increasing.

Conversely, if the ratio of NMVOC:NO_x is high (i.e. there are low levels of NO_x) the main inhibition mechanism for O_3 production is the removal of NO_2 (figure 2.5) by RO (NMVOC derived from NO_2 + RO_2). While the reduction of the NMVOC concentration may result in the increased availability of NO, it will also result in an increased availability of NO_2 and therefore reduction in ozone concentration will be negligible. The result is that in areas where NMVOC concentrations are relatively high, reduction strategies concentrating on NMVOC management are ineffective at curtailing O_3 production.

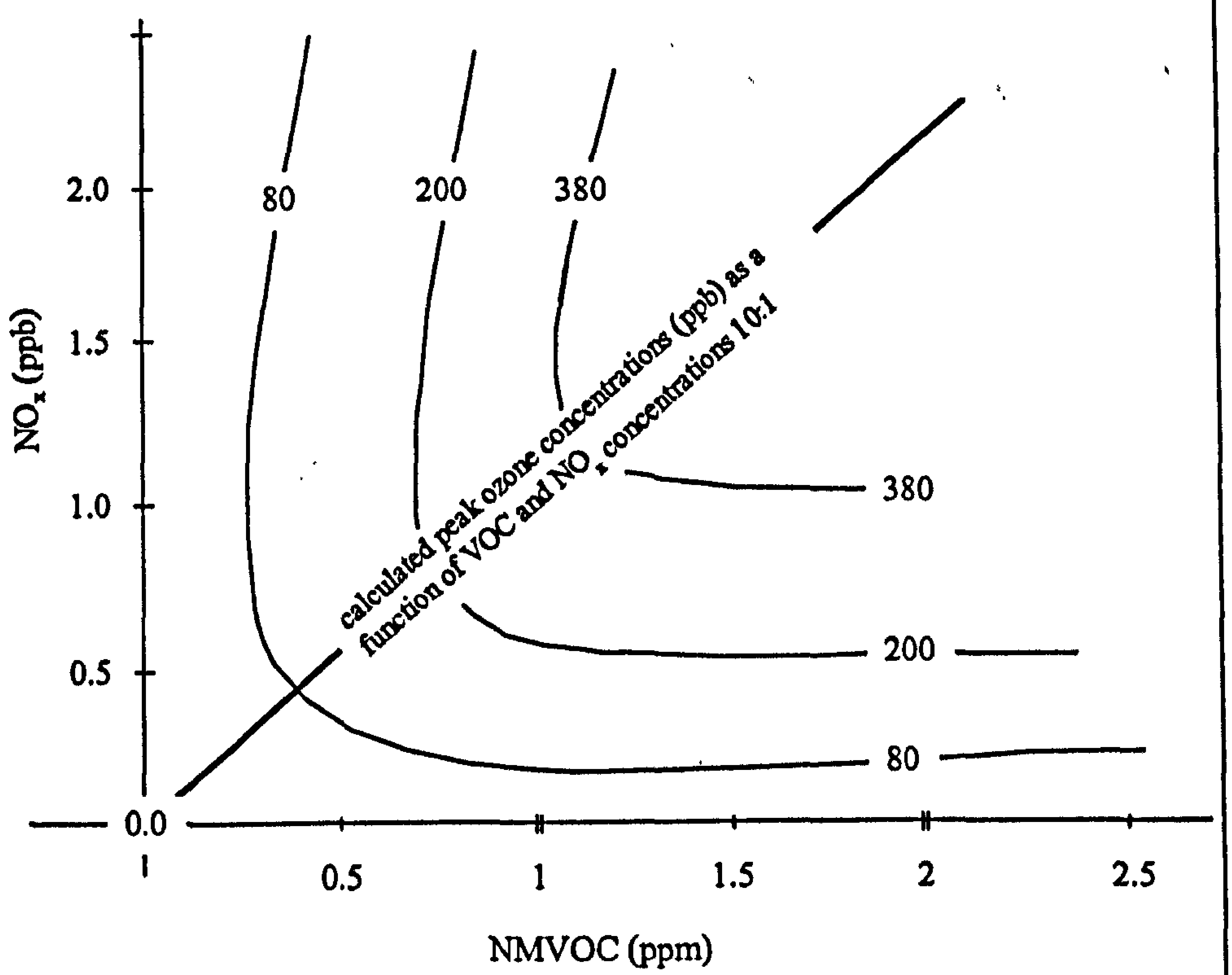

Figure 3-6: The Relationship Between Precursor Ratios and Ozone Concentration (adapted from Chameides, 1994; and Huess and Wolffe 1993)

3.4 The Spatial and Temporal Nature of Tropospheric Ozone

This genesis of ozone from NO_x and NMVOCs as well as its accumulation, occurs over a period of several hours (McKendry, 1993) downwind from areas typified by high NO_x and NMVOC concentrations. This tends to lead to the forming of pollution flows where densely populated urban areas form sinks for ozone precursors, while in themselves the ozone concentration is fairly low due to scavenging by the high concentrations of NO (McKendry, 1992). The result of this process is the formation of ozone rivers (Wolf and Lioy, 1980) where ozone forms an urban plume and accumulates in more rural areas down wind (see figure 2.7), an effect that may be increased if there are significant emissions of natural NMVOCs in the rural area (illustrated in chapter 5).

While high ozone concentrations are associated with rural areas, temporal factors also play an important role in incidents of high O_3. A major study carried out in Canada (McKendry, 1993) found the following temporal factors to be important:

Diurnal: A primary peak in O_3 concentration was associated with the period between 11:00 and 14:00, coinciding with the period of highest solar intensity. A secondary peak was also recorded early morning prior to the rush hour and is thought to be

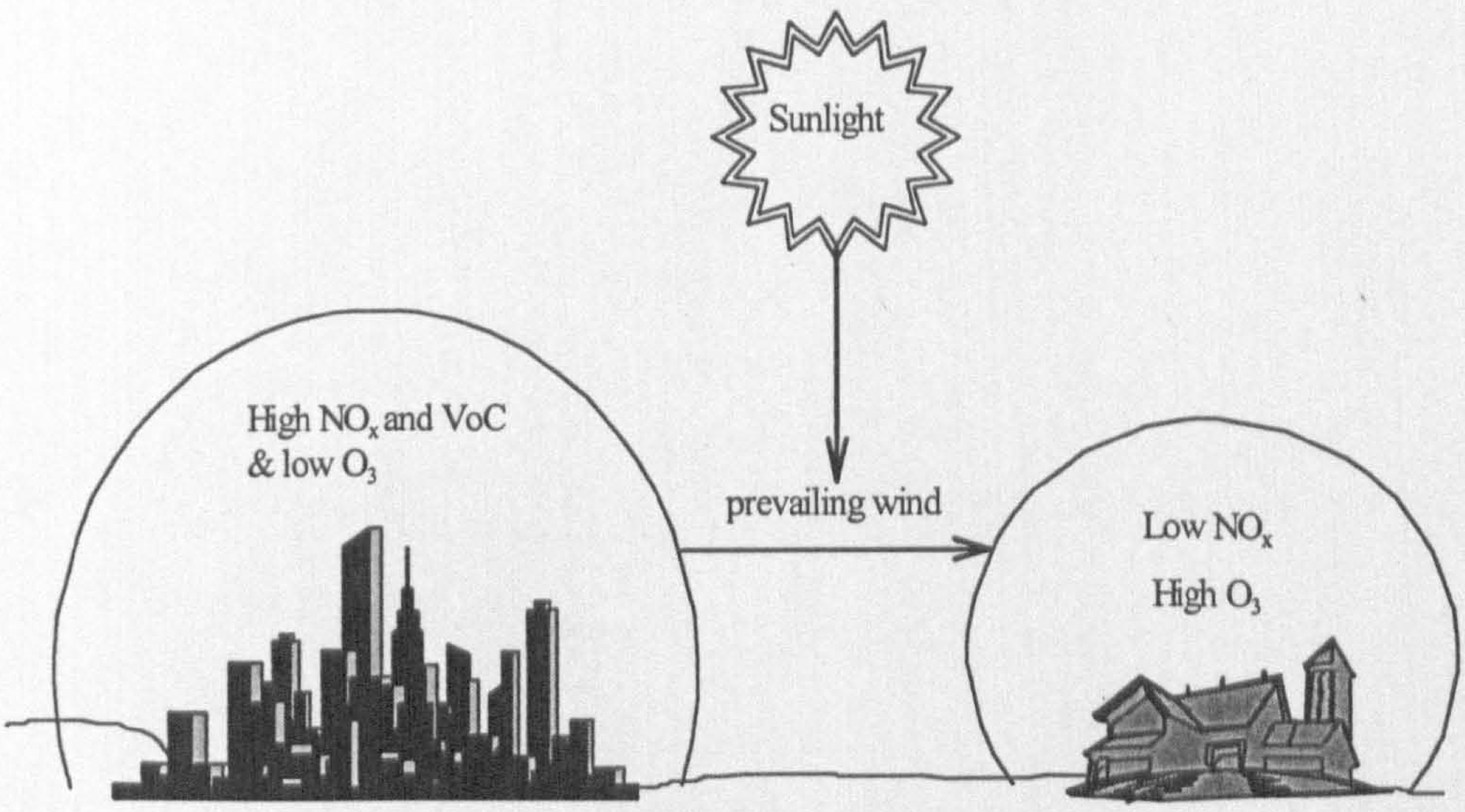

Figure 3-7: The Migration of an Ozone River

associated with a lowering of the urban inversion layer allowing less atmospheric mixing. During the early morning and late afternoon there where distinct troughs in O_3 concentration. It has been suggested that this is due to the higher concentration of vehicle emissions during these times (rush hours) and therefore excess scavenging of O_3 by NO (figure .1).

Seasonal: The concentration of ozone fluctuates markedly from winter to summer, with summer concentrations notably higher. While the city acts as a precursor sink during both winter and summer, this effect as well as the strong diurnal variations are less marked during the winter. It is also interesting to note that the seasonal fluctuation in O_3 is reflected by the opposite effect in NO, where winter concentrations are high due to lowered boundary layers and higher stability of NO_2

Interannual: The climate varies from year to year and as would be expected those years where the climatic conditions synoptic to ozone production are more frequent, tend to produce a greater number of high ozone episodes. Future climatic changes resulting in more summer anticyclones and associated clear skies may more than neutralise any benefits from reductions in in automobile emissions (Chamiedes, 1994).

These temporal peaks in tropospheric ozone are therefore dependent on two major variables; Firstly climate, i.e. the number of days where sunlight intensity is high, and slow moving anticyclonic weather systems develop; and secondly the concentration of ozone precursors at the source area of the urban plume. The importance of these factors in defining the quantity of O_3 produced is illustrated by a large study into the effect that daylight saving time has on the magnitude of O_3 peaks (Hecq and Borisov, 1993). This study has shown that the severity of pollution may be significantly altered by shifting the periods of traffic intensity in respect of periods of high sunlight *(vh)* intensity.

These migrant and synergistic features of O_3 production mean that the source of the pollutant (i.e. high density urban traffic) is distant from the perception of the problem. In other words the localities where NOx or NMVOCs are problem pollutants tend not to be the areas where O_3 is a problem or vice versa. NO_x and NMVOCs are pollutants in their own right with associated health effects as severe as those of O_3 and have set air quality standards. Furthermore, these set standards are more stringently incorporated into present legislation than those for O_3 (DoE 1996, see chapter 5).

It can be seen that the management of tropospheric ozone involves some very subtle technical problems. However, these are also compounded by the overlaying problems concerning the issue of air pollution and the cause of the pollution within the society in which the attempted management of these problems is taking place.

One of these is the difficulty in defining ozone as an impact on human health in the area where the substance is perceived as a problem. This problem is made more difficult when it is recognised that one must compare the impact of this with other issues such as those asscoiated with Nox, a polluatant that is thought to have similar effects (Committee on the Medical Effects of Air Pollution, 1995) but will scavenge and be scavenged by ozone in any particular location.

3.5 The Health Effects of Tropospheric Ozone

It has been known for about forty years that the oxidising effect of tropospheric ozone can have derogatory effects on mammalian lung tissue (Stokinger, 1957). However, there is still debate as to what constitutes a standard response to changing ozone concentrations (Committee on the Medical Effects of Air Pollution, 1995; Lippmann, 1993) and what characteristics of ozone exposure are important in eliciting a chronic response (Allen, Foley et al., 1993).

The two approaches presently used to establish the human health effects of tropospheric ozone are toxicological studies where human or animal test subjects are exposed to different concentrations of ozone under controlled conditions, and epidemiological studies where the effect on natural populations of changes in ambient ozone concentrations (among ambient effects of other variables) are monitored.

Such studies have resulted in the establishment of some fairly well documented trends associated with raised O_3 concentrations (Lippmann, 1993), an increase in the rate of hospital admissions for respiratory diseases (Thurston et al., 1992), increased rates in severe lung structure abnormalities in young people (Sherwin, 1991) and possible mortality (Kinney & Ozkaynak, 1991 (Anderson and al. 1996; Sartor et al., 1996). Direct quantification of these effects has however proven difficult due to the wide range of uncertainties concerning both the causes the any effects and whether these effect are actually significant.

Although popularly associated with asthma[5] epidemiological studies into the prevalence of this syndrome with respect to increasing tropospheric ozone concentrations have proved inconclusive (Ball et al. 1996; Committee on the Medical Effects of Air Pollution, 1995). This may be due in part to the fact that it is difficult to study the effect of ambient ozone in isolation from other pollutants and factors such as climate, background infections, and non-gaseous triggers (Allen, Foley et al. 1993;

[5] Bedfordshire on Sunday (22/1/1995) *Ozone Levels the Worst in the Country*

Ayers, 1996) as well the complex nature of asthma. The present stance of contemporary research is that other factors such as secondary smoking, pollen triggers and diet seem important in that causing an individual to suffer the asthma syndrome, and air pollution has little proven role to play (Ciba Foundation, 1996). However, it has been conjectured that O_3 (or air pollution in general) may enhance the susceptibility of asthma sufferers to attacks (Committee on the Medical Effects of Air Pollution, 1995).

The overall situation may well be that secondary triggers and air pollutants may act in concert. For example, it has been shown that links do exist between ambient ozone concentrations and an individual's susceptibility to pollen as an asthma trigger (PORG, 1993), and that hot humid days are influential in causing asthmatic-type response in young children (Sartor et al., 1996). Although sort after, direct causal linkages between tropospheric ozone and asthma have not been proven (Committee on the Medical Effects of Air Pollution, 1995; Peters, 1996; Ball, 1996; Devereux, 1996; Lee, 1992). Furthermore while the incidence of asthma does show seasonal variation, this seasonality shows very little similarity with that of high O_3 events.

Instead of being able to show an easily recognisable impact of ozone on human health, toxicological studies have shown that the dose-response relationships between health effects and ozone are complex and have been found to depend on two major variables (Allen, 1993);

- The inherent sensitivity of the individual to ozone: where stronger effects on lung function (Spinx et al., 1992) relate to age and health. The youngest and oldest are and those whose bronchial health is poor most sensitive (Allen, 1993), and
- The pattern of exposure which in turn depends on the parameters of exposure duration, ozone concentration and the volume of air breathed during the period of exposure (Allen, 1993).

However, the relationship between these parameters has been shown to be complex since it has been found that O_3 concentration multiplied by exposure duration does not reflect toxicity as the rate of lung activity increases and research shows that concentration may be the most important factor in eliciting a toxic response and the effects shown may be cumulative (Allen, 1993).

In a review of toxicological and epidemiological studies Lippmann (1993) concludes that exposure to ozone may produce both short term transient effects and long term health effects depending on the exposure characteristics of the population.

Short term effects of ozone on lung function can be brought about by prolonged daily exposure to concentrations as low as 80 ppb, or by repeated exposure to hourly peaks of 120 ppb. These effects include: changes in lung capacity; changes in flow resistance; increasing epithelial permeability; reactivity to bronchial irritants. It has also been shown that these effects may last for many days after the exposure ceases and that cumulative exposure to elevated ozone concentrations may heighten and prolong these effects.

Another toxicological study (Linn, 1991) found that while exposure of healthy adult males to 120 ppb O_3 in purified air could produce a significant reduction in lung flow and an increased bronchial sensitivity to irritants, these responses were attenuated on the second day of exposure. Further evidence suggests that this resistance may increase over a period of five days and the effects may become negligible. Lippmann (1993) and Linn (1992) also found a similar pattern in asthmatics subjected to the same O_3 concentrations but with enhanced effects.

This research may indicate two points:

- adaptation to high levels of O_3 may occur
- asthmatics may be more sensitive to the health effects of high O_3 concentrations.

It should be noted at this point that while resistance to the short term effects of elevated ozone may be apparent, toxicological studies carried out on rats indicate that while a response comparative to that seen in humans is shown, progressive damage to lung tissue and structure is not abated. Furthermore prolonged exposure to high ambient levels of O_3 in human populations has been linked to premature ageing of lung tissue, reductions in base-line lung function (Lioy et al, 1985) and increased mortality. It has also been suggested that these effects are significantly enhanced at lower O_3 concentrations in the presence of other pollutants (Lioy & Dyba, 1989).

Toxicological and epidemiological research suggests that the most important features of ozone exposure (in relation to the magnitude of health effects) may not be the period of exposure to average concentration, but the number of exposures to peak concentrations in a set time period (Allen, 1993). Temporary health problems may occur as a result of repeated exposure to hourly peaks of O_3 concentrations of 120 ppbv (even when average measures are well below guidelines for average hourly or eight hourly concentrations). Furthermore, while the population may become resistant to high ambient O_3 levels, sporadic exposure to peak concentrations may produce cumulative responses, especially within the early part of the high tropospheric O_3 season and there is no evidence that resistance in the population may occur as a result of long period exposure to relatively low concentrations of O_3 (Lippman, 1993).

While there is evidence to suggest that health effects may be more prevalent in younger and older populations it has also been shown that health effects of equivalent O_3 concentrations are more severe in groups subjected to ambient air than purified air. This feature may be due to the fact that control groups are subjected to constant concentrations while those exposed to ambient air are subject to peaks (Allen, 1993) or because populations exposed to ambient ozone are also subject to a range of other pollutants.

In summary (see figure 2.7), the state of the knowledge in epidemiological and toxicological studies into the effect that tropospheric ozone has on the human physiology can be summarised as:

Chronic exposure (either prolonged levels of between 80 - 100 ppb, or serial exposure to a number of hourly peaks over 120 ppb) which is especially likely to elicit strong transient short term effects of reduced lung function.

Synergistic exposure in conjunction with other pollutants, which may produce more apparent effects at lower concentrations of O_3.

Selective exposure of sensitive groups such as the young and old and those suffering from pneumonic illness (such as asthma and bronchitis)

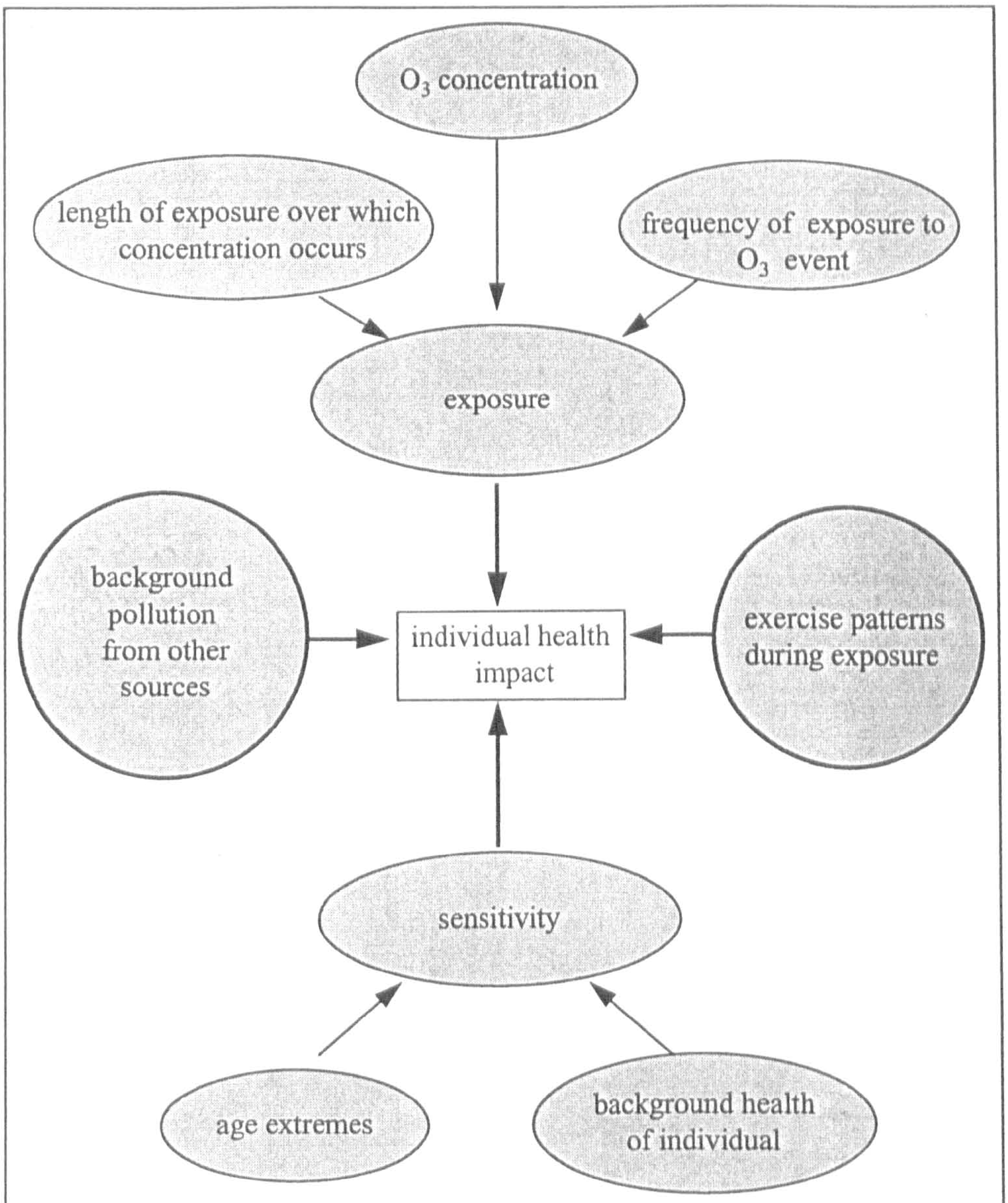

Figure 3-8 Factors affecting physiological response to tropospheric ozone

In addition to these features it has also been suggested that populations exposed to long term high O_3 levels may exhibit irreversible long term lung disorders and premature ageing of lung tissue which may take many years to become apparent.

3.5.1 Air Pollution as a Perceived Impact

Traditionally policy formulation in the area of air pollution management has restricted itself to the consideration of best scientific evidence when considering impacts of pollutants and setting goals for their amelioration (see chapter 3). This tradition is still prevalent today (DoE 1997, DoE 1995). When one considers that car driving is ultimately a problem of general behaviour, and that how people behave is a reflection of their values and perception (Hadfield, 1997; Ahuja 1996; and North, 1992), then one can also see that it is not only epidemiological impacts that are important to the population but also the more subjective perceived impacts of air pollution. In other words, the way in which the people affected by the pollutant that they are impacted upon, and how these relate to the perceived benefits of the activity that causes the pollution.

An overall effect of the way in which exposure to air pollution affects health is that there is a great degree of uncertainty. While popularly associated with asthma (DoE 1997)[6] there is no evidence that this is the case, and the official stance is that air pollution from motor vehicles in general represents a very small risk to the average individual and is of significance only to those sectors of the population which are sensitive. However, while this is the stance of policy, there is to a significant degree a variation in the level of concern about air pollution among the population (Hadfield, 1997) and this concern over may change depending on very localised features in the environment. This is shown in the following quote:

> *"Predictably, communities close to the landfill sites were more concerned about them than those further away, and respondents in the villages were more concerned about agricultural pollutants, sprays and pollens, than those in the urban area, although there were some surprising results, suggesting that factors other than distance, for example, wind direction, are also relevant. In general, sources mentioned could be divided into: immediate and diffuse sources, (e.g. traffic, domestic heating); locally significant point sources, (e.g. the crematorium in one area, the sewage works in another); and major regional point sources, (i.e. brickworks and landfill). Over half (55%) of all responses mentioned pollution sources within 5kms"*[7] (Hadfield and Cannibal 1996)

It is proposed that both the quantitative and qualitative nature of the issue can change depending on the area over which it is viewed. Furthermore, air pollution is only one issue under consideration among many such as the benefit people derive from the use of the motor car and how this compares to these concerns over the impact the car has on the environment (Acury & Christianson 1992; Hutton and Ahtola, 1991).

3.6 The Source of the Pollutant, Transport as a Function of Modern Living

The fact that the main contributor to tropospheric ozone in the UK, especially in the south central area of the country (see figure 3.2 and 3.3), is the wide use and availability of the motor car is not in dispute. This fact is reflected in much of the recent EU and UK policy aimed at controlling air pollution (PORG, 1993; Quality of Urban Air Review Group and DoE 1993; DoE 1997) and is illustrated in figure 3.8 as

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[6] for example BBC Horizon Program (1993), *"Allergic To The 20th Century,"* 10th May; The Times (1994) *"Schools May Be Closed To Keep Parents Off The Road,"* 5th July, p5; The Times (1994) *"Motor Vehicles Leave Toxic Legacy,"* 11th January, p8; The Times (1994) *"Poison For Toddlers,"* 18th February, p21; The Times (1994) *"Something Unhealthy In The Air?,"* 12th February, p3; The Times (1994) *"Revealed: Pollution Black Spots of Britain,"* 10th July, p5. The Times 1996 *"Asthma Treatment Costing NHS £410m,"* 21st August, p 4; and Bedfordshire on Sunday (1995) *"Ozone Levels The Worst In Country,"* 22nd January.

[7] *taken from a the results of a survey into the attitudes of local parents in Oxford 1996 by Dr. L. Hadfield as part of a Ph.D. study*

well as the following quotes from local authority planning and Environmental Health Officers[8].

> *"But in this part of south-east England, that's just the way it is, we haven't got industrial polluters, we've got traffic and god knows what we're going to do about it"*
>
> (Oxford City Council Environmental Health Officer, 1995).

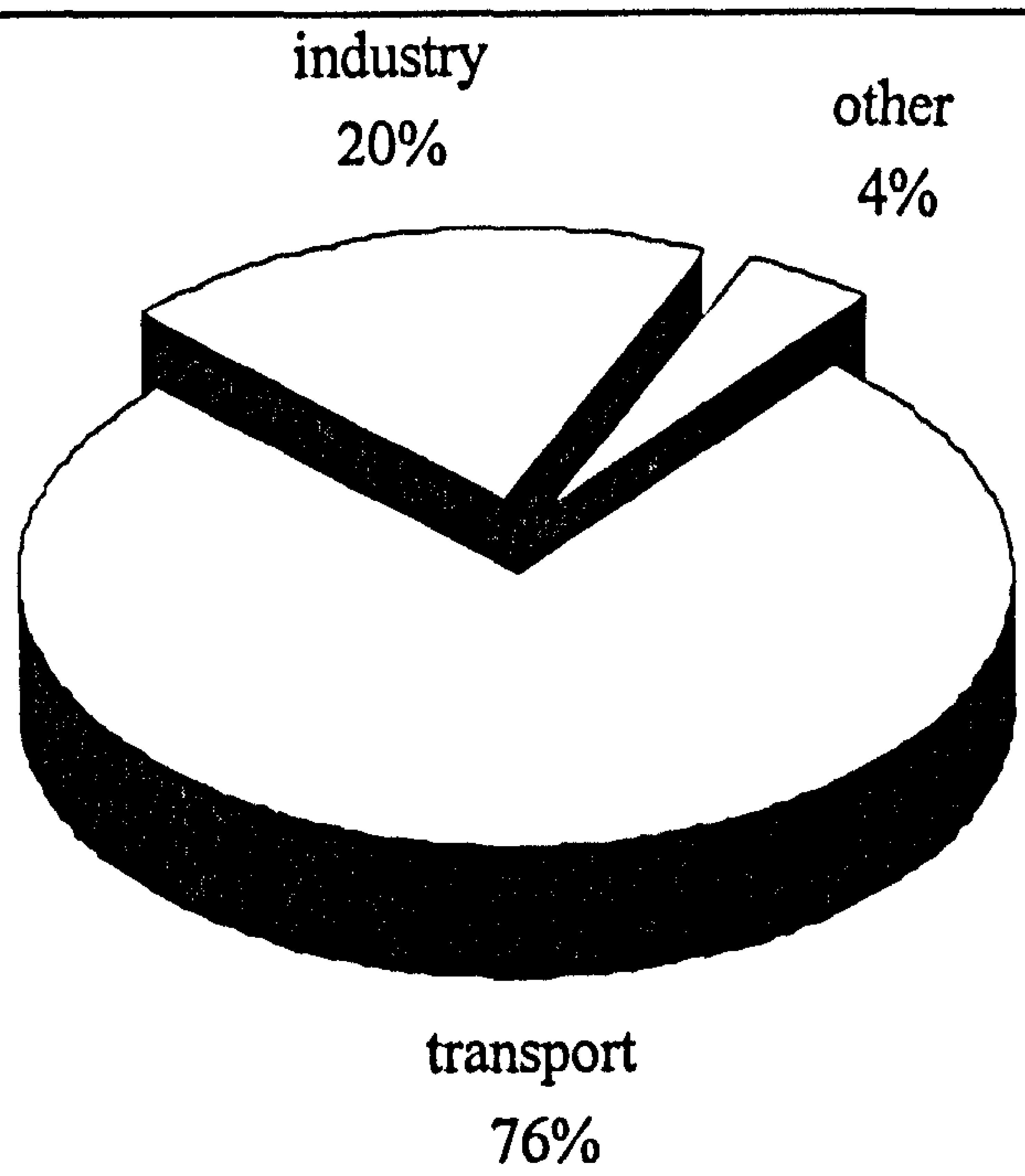

Figure 3-9: The proportion of European Union (EU) air pollution policy aimed at controlling emissions from road transport compared to other sectors

> *"National figures indicate that the major source of air pollutants now, apart from if you're near a gross point-source, is traffic. We have a very busy motorway running right through our area"*
>
> (Bedford Borough Council Environmental Health Officer 1995)

The contribution of road transport to tropospheric ozone precursors has been steadily increasing despite the growth of emission control devices such as the catalytic converter (Air Health Strategy, August 1996; Air Health, January, Strategy 1997). This is mainly due to the fact that ownership and use of private transport has grown dramatically over the last twenty years (see figure 3.9) within an environment of relatively lower car prices, cheap fuel and a predict-and-supply approach to road infrastructure provision (SACTRA, 1992). In order to address this problem there has been a recent shift in DoT policy away from merely accommodating this growth to

[8] Hadfield, (1994)

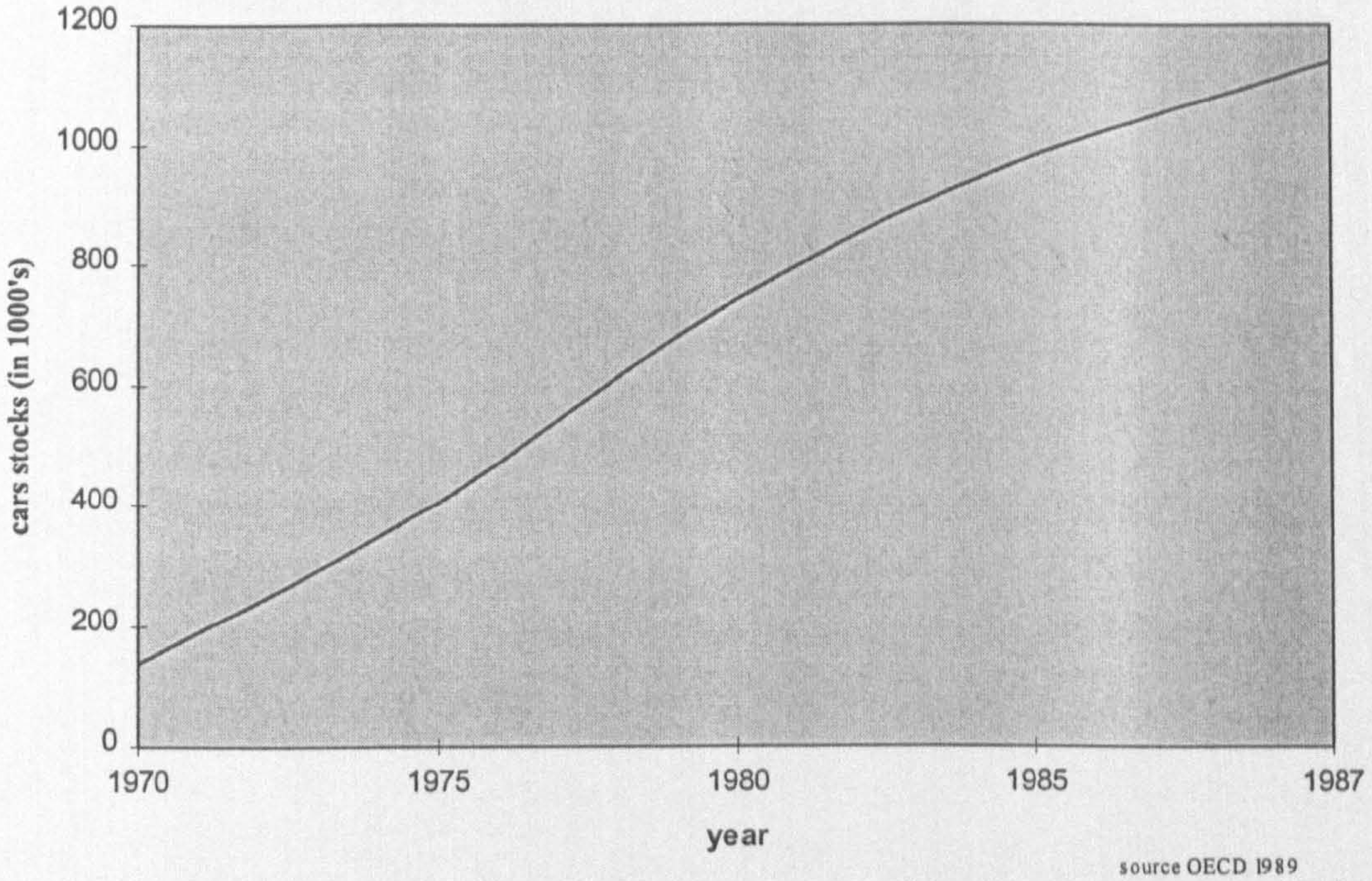

Figure 3-10: The growth in private car stocks in the UK during the 1970s and 80s

attempting to manage it. For example fiscal measures such as increases in the duty raised by road and fuel tax as well as allowing local authorities to impose financial disincentives on parking and encouraging planning policies that reduce the need for road transport (DoE, 1997).

There is a growing recognition that air pollution and transport management are closely linked (DoE 1997). This moves the emphasis of air pollution control away from the restricted role of controlling point source emission through permits and penalties (NSCA, 1995) to one of managing road transport. However, despite attempts in the UK within the last decade or so (Air Health Strategy, December, 1996; Air Health Strategy, February, 1997) and for longer in the USA (Chameides, 1993), the growth in traffic and associated degradation in air quality of the 1980s and early 1990s remains unabated. It has been suggested that one of the main reasons for this is the complex and interconnected nature of road transport and other aspects of our physical and social environment.

3.6.1 The Derived Nature of Road Transport

The early theory on urban transport assumed that transport was a basic single function that allowed people to get to work, and that therefore the investment in transport infrastructure needed between any two points equalled the "attractiveness" between these two points (Foot 1981). Although this approach quickly became redundant in the field of transport theory[9] due to its overt simplicity[10] it does represent, an early

[9] although it is still applied commonly in modern transport planning (Webster, Bly et al. 1988)

recognition that transport demand and usage were related to urban form and that access to transport then allowed for more dispersed living patterns (RPTI, 1991; OECD, 1993). Therefore unlike the industrial pollution of the past, road transport related pollution is not the result of a discrete action but rather is derived from the way our society has ordered itself (Lowe, 1992).

In response to the growing awareness that road transport use and demand is firmly located within the physical structure of our towns and cities and the fact that changes in one affect the others (Webster, Bly et al., 1988), there has been a move to integrate transport and land-use planning functions in both central government guidance and local authority departments and policy (Chapters 4 and 5).

However, it has also been suggested that this is an oversimplification of the situation. Transportation patterns are implicitly linked to our way of life, the shape of our cities and the well-being of our economy as well as the sense of personal freedom and security most of us enjoy (see chapter 6). The move to dispersed life-styles and the rise of the ownership of the private motor car do not represent a simple causal link but are both a consequence of changes in the wider social fabric which have taken place in post-war western society. Other factors are also important, such as increased relative incomes, increased leisure time, smaller households and increased expectations over the material quality of life (Wagener, 1993) mixed with low fuel prices and increasing financial accessibility of car ownership. These features make the management of transport derived air pollution an extremely complex problem involving a wide range of political, technical and social issues concerning different interests and professions (OECD, 1990). While this has resulted in a general acknowledgement that urban planning, transportation and environmental policy need to be linked (DoE, 1994a; DoE, 1994b; DoE, 1995; DoE, 1997) the management responsibility for the biophysical and social features of this problem rests within an incomplete, disciplinary and spatially fragmented structure (Longhurst et al., 1996; Cannibal et al. 1996) which is not consistent with the need for an understanding of how the built, physical and social aspects of the environment interact (Taylor, 1990; Lowe, 1992).

3.7 Policy Implications

The policy control of air pollutants has traditionally been centred around the technical control of individual pollutants from a point source in a restricted locality (NSCA, 1996; DoE, 1996). However, the issue of tropospheric ozone presents the policy maker with a whole range of new problems.

This chapter has illustrated why the problem of elevated levels tropospheric ozone is complex, in terms of its source, transformation and reception (see figure 3.10). The source of the pollutant, viz. the use and availability of the private motor vehicle is deeply ingrained in modern western culture (especially that of the UK which has one of the highest uses of private road transport in Europe (OECD, 1993). In many ways it is only private transport that can fulfil the function it is used for, often due to the lack of any alternative (or a lack of personal knowledge of any alternative). A situation that has come about since many of the activities carried out using private transport have

[10] for a more in-depth review of the evolution of transport theory and models the reader is directed towards Batty, M. (1979); Batty, M. (1994), Harris, B. (1994), Lee, D. B. (1973), Wagener, M. (1994).

come to be a central feature of the way people behave and order themselves in modern western society, due to the availability of the private motor-car (Vickers, 1984).

Another main problem arises when one considers the nature of the pollutant, in that this particular substance is not emitted directly and does not impact in the same locality as the source. Rather the pollutants tend to impact in areas that are

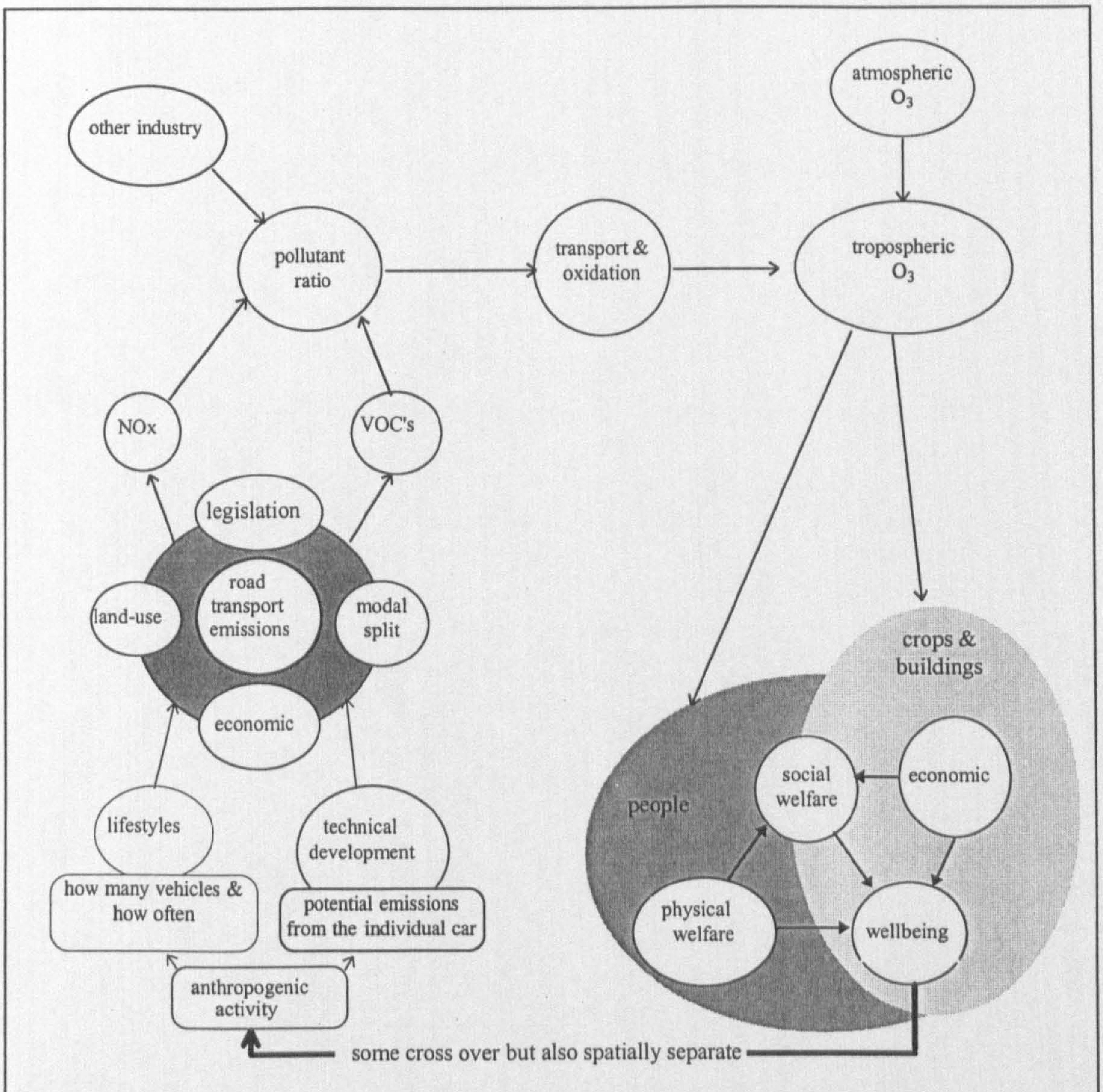

Figure 3-11: Production and Reception of tropospheric Ozone: a case of complexity

quantitatively and qualitatively different in nature to the area where the precursors are emitted. Since the precursor substances are also regarded as pollutants, with associated guidelines, there could be an argument for local control of these emissions in order to reduce tropospheric ozone. However, the non-linear nature of the interaction between these substances causes problems.

Local emission controls of NOx in an affected area would be very inefficient in reducing the magnitude of the peak tropospheric ozone concentrations and may actually lead to an increase in ozone concentrations due to the removal of the NO scavenger in the system (section 3.3). Optimal control strategies of precursors at source may effect an improvement in these down-stream O_3 events but not approach the issues concerning air quality in that source site, since areas where NOx is high require a reduction in NMVOCs and vise-versa (Seinfield, 1993). However reduction strategies at source are likely to impact on the lifestyles and activities of people in that area without showing any obvious gain to that population.

A further feature of this system is the high degree of uncertainty concerning the effect of ozone (as well as its precursors) on human health and the way in which knowledge of these impacts is interpreted by the population and policy makers as a whole. Even from the restricted view of epidemiological and toxicological studies into the effect ozone has on human health, one may deduce that air quality standards may be too lax. However these are held as a tool for achieving a significant improvement in the well being of those who are identified as "*at risk*", such as the elderly or people who have lung disorders (DoE 1996).

Evidence suggests that the most important features of ozone exposure in relation to the magnitude of elicited health effects may not be the period of exposure to average concentration, but the number of exposure events to peak concentrations in a set time period (Allen, Foley et al. 1993). Temporary health problems may occur as a result of repeated exposure to peaks of O_3 at concentrations of 120 ppb, even when average measures are well below guidelines for average hourly or eight-hourly concentrations (that of 90 ppb). Furthermore sporadic exposure to peak concentrations may produce cumulative responses, especially within the early part of the high tropospheric O_3 season.

While there is evidence to suggest that health effects may be more prevalent in younger and older populations it has also been shown that the health effects of equivalent O_3 concentrations are more severe in groups subjected to ambient air than purified air injected with O_3. This may be due to the fact that control groups are subjected to constant concentrations while those exposed to ambient air are subject to peaks (Allen, Foley et al. 1993). It has also been suggested that this may be a result of the fact that populations exposed to ambient ozone are also subject to a range of other pollutants working in synergism. In addition to these problems, the long term effects of O_3 exposure (such as permanent lung disorders and premature ageing of the lung tissue) may occur as a result of long periods of exposure to relatively low concentrations of O_3 (Lippman, 1993) that are far below those recorded in tests as being causitive of short term health effects.

Therefore, rather than just the immediate background concentrations being important, individual life styles are relevant in regard of the effects the pollutant may have. These life-styles may include movement patterns that affect which the frequency of exposure, and activity patterns that may be a very significant feature in the elicitation of health effects. Many of the health effects associated with the pollutant only become apparent after years of exposure to low O_3 concentration.

While these features are far from proven, there is the implication that management of air quality to set air quality standards cannot easily identify a direct benefit to health. Furthermore at present there is a wide range of opinions concerning these health effects being publicised by various sources (Committee on the Medical Effects of Air Pollution, 1995). Furthermore, people themselves tend to view air pollution generically and in terms of what is going on in their own back yard (Hadfield and

Cannibal, 1996) rather than on the basis of epidemiological and environmental knowledge and their values and actions tend to be driven by these concerns (see chapter 4). These also tend to be the concerns which elected policy makers must represent within the constraints limited resources (see chapter 8).

Within the aim of controlling road transport derived ozone, the values and actions of the car driving public are a major issue, and management needs to be able to influence them (Taylor 1990). The following section in this chapter proposes that a new approach to environmental management is needed for this type of behaviourally derived pollutant: An approach that can influence our culture as a whole, and is generally acceptable to the individual and society alike. This requires not only a scientific understanding of the problem, but also a deep understanding of the social causes of the problem and how their impacts rate as an issue among the population compared to the importance attached to the provision of cheap and available private transport.

3.8 Air Quality Management as a Cultural Problem

> *"Irrespective of the problems associated with them, social goals and objectives are the keystones of decision-making activity. Plans and proposals prepared in ignorance of these goals have little chance of being accepted and implemented. The challenge is to exercise our technological skills within the bounds of institutional realities and in a manner accommodating of both society's preferences and the principles of efficiency"*
>
> (Viessman, 1988)

The following chapters will illustrate how institutions and strategies in environmental management have evolved over the last two decades to manage what are often perceived as localised direct health effects amenable to technical solutions (see chapter 4 & 5). This point is reflected by concepts such as BATNEEC (Best Available Technology Not Entailing Excessive Cost) and the establishment of air quality as a Local Authority environmental health problem (under the 1953 Clean Air Acts). However, many of the problems faced by contemporary society are subtly different and can be described as a class of emergent phenomena which are the unintended consequence of recent social development, regarding how our society has ordered itself.

This chapter proposes that road transport-derived tropospheric ozone is a good example of such a problem. The main source of the pollutant is diffuse and distant from its impact. It manifests itself in different locations and at different times as qualitatively and quantitatively different pollutants (Chameides, 1993; Huess and Wolffe, 1993; Elsom, 1996). Tropospheric ozone rests in the category of derived pollutant in that it is not directly emitted but the product of the interaction of other pollutants. It is to a great extent a result of common individual behaviour, i.e. the use of the car which is not usually an activity in itself but more commonly a medium by which a whole range of other activities are carried out (Lowe, 1992; Wagener, 1993). In addition to this problem, transport related pollution poses another riddle for the policy analyst in as far as the problem of its impact on the environment is generally accepted: surveys among the general public show that, while people agree with the need to reduce private car use, this opinion is not as a whole supported by individual action (Arcury and Christianson, 1992).

Despite the nature of the pollutant, which has been described as the UK's most important air pollutant (Longhurst, Lindley et al., 1996), the approach laid out in present UK central government policy holds the individual health effects of each pollutants as its driving issue (DoE, 1997). This single pollutant approach is supported by the stated belief that there are no significant synergistic health effects brought on by multiple pollutant exposure (DoE, 1997). The regional nature of the interrelationship between O_3 and its precursors is not mentioned. NOx and tropospheric ozone have their own air quality standards, while the VOCs have selective standards[11]. These standards are not designed with any consideration of a comprehensive regional ozone strategy (see chapter 5).

This situation is likely to be continued under the growing influence of the European Air Quality Directive (Commission for the European Communities, 1995). Air quality standards (AQSs) will be set at a European level within the context of economic harmonisation (Linter and Mazey, 1991) and legislated at the national level as an across-the-board set of standards (Faulkner, 1991). They do not take into account local conditions of air flow and differing issues sets faced by the local authorities that are left with the main job in implementing them (Hadfield, 1997).

This study proposes that the following issue sets surrounding variations in both the physical and social nature of the problem are particularly problematical within the present framework for tropospheric ozone management.

3.8.1 Variations in Air Quality Issues Related to Scalar Resolution

From a local perspective, pollution control standards demand an improvement in air quality in a specific area inhabited by the population to which the authority is directly answerable (Hadfield, 1997). It will be shown that monitoring of air quality is the role of the local authorities, as is much of the remit for controlling road transport emissions (chapter 5). The local authorities, however, are caught between two levels. On the one hand they recognise the need for regional and national management of issues of air quality which are affected by factors lying both geographically and institutionally beyond their control. On the other hand, they need to be responsive to the residents in their districts, whose concerns and perceptions are more likely to be affected by what occurs in "their own back yard", and who expect "the council" to deliver acceptable air quality on this basis and on their own terms. Indeed answering these complaints accounts for the spending of most of the time and financial budgets of local environmental health departments (illustrated in chapter 8). In this instance air pollution is not always top of the local agenda as an environmental problem, at either the local population level or local political level. Furthermore the issue is often defined by local populations in very different terms than it is in the national and European legislation (figure 3.11).

[11] A wide ranging standard for these compounds was recently blocked by the Department of Trade and Industry on the grounds that the economic impact of such standards on industry would outweigh the benefits. The role of VOC's in Ozone production was not considered (Brown 1994).

This situation is also complicated by the fact that local authority departments are working within what is generally recognised as a very limited monetary budget resulting in resource and time based constraints (see chapter 8) within a state of affairs where it has been stated by central government that any extra funding local authorities will receive to meet its duties resulting from the 1995 Environment Act will be restricted purely to those of a statutory nature. In this situation, top down imposed goals and standards may well become a constraint to the management of more immediate issues relevant to the local population, resulting in a perceived decay in environmental standards.

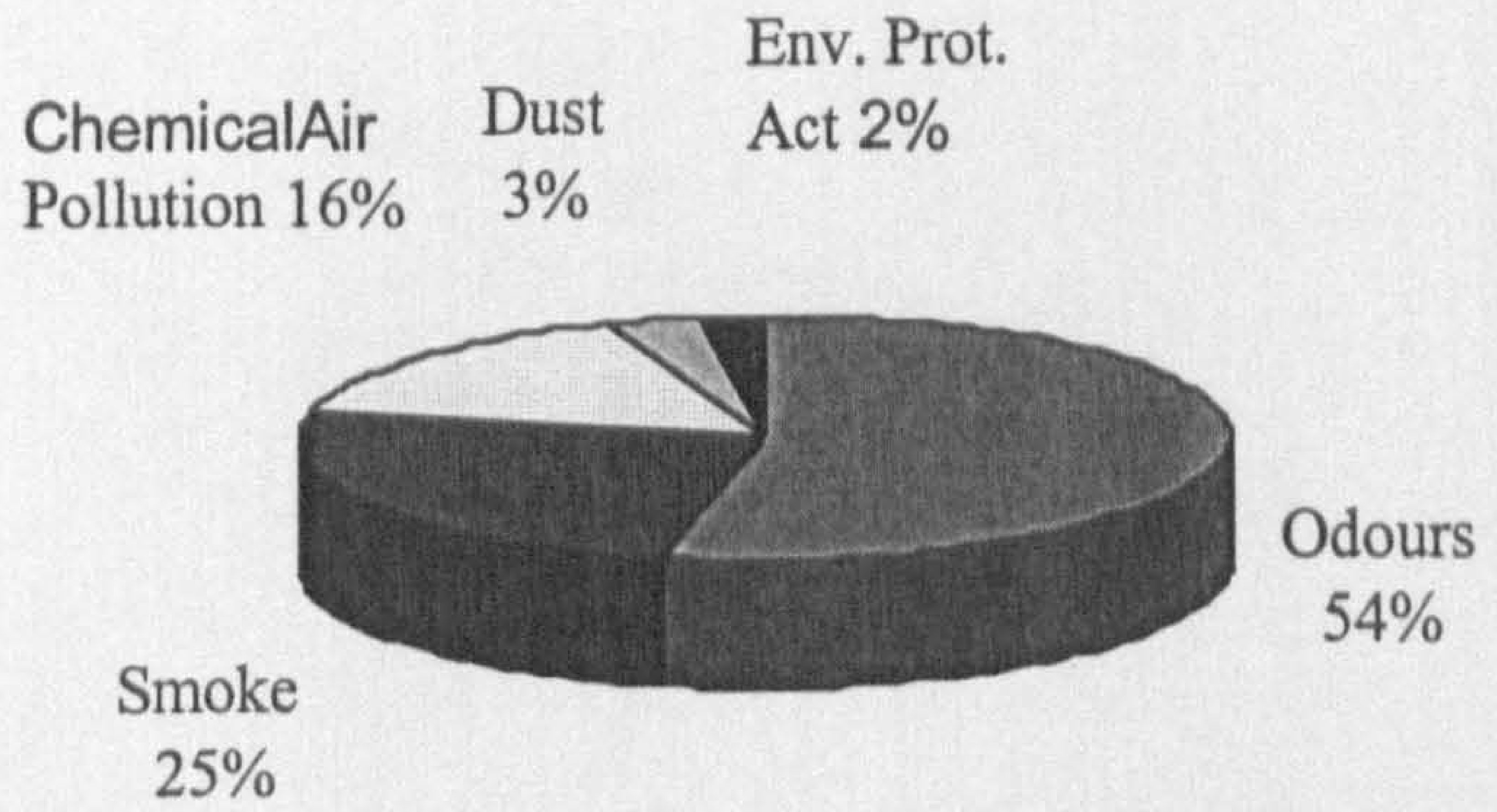

Figure 3-12: Breakdown of complaints over Air Quality, 1996/97: *shows that public concerns as represented by complaints to local authority Environmental Health Departments are expressed in terms of what are the most sensory apparent effects. Air pollution from chemical source tends to be seen generically and is of much less concern than odour and smoke (source Bedford Borough Council 1997).*

3.8.2 Reconciling Conflicting Issues Within the Social and Biophysical Environment

A second major issue is that individuals within a locality are not only living in the biophysical aspect of their environment, but also within a social system of activities, and life-styles that have evolved as a feature of that locality. Therefore, within any area there is the problem that a democratically elected authority must also be empathetic to not only the impact but also the utility that the activity causing air quality degradation holds for that population, as well as the other values and interests surrounding the activity (an issue explored in chapter 7).

This view has been expressed in much of the planning literature and the conflict inherent in the duality of the needs to balance the interest of the local economy while safe-guarding or improving air quality is well noted (European Conference of Ministers of Transport 1990; SACTRA, 1992; Department of the Environment and Department of Transport, 1993; RPTI, 1991). It is a long standing bug bear in the history of air quality management (see chapter 4).

It is proposed that modern management of air quality implies the need to control the heavy and growing use of the private motor vehicle, not in a straight-forward generic manner, but selectively in different locations depending on the local aspects of the regional pollutant profile.

3.8.3 Variations in Social Issues Related to Scalar Resolution

From a social perspective, control strategies aimed at reducing the use of private transport life may strongly affect the individual who is the recipient of such policy (a feature explored in chapter 7). Control will need fine tuning to fit in with regional air flows so as to be shown to be beneficial to the individual at whom the control is aimed.

Studies aimed at devising air quality management strategies need to be able to assess the situation fully in terms of both an overall regional picture of the cause and effects of the pollution episodes as well as the social context in which they sit. In the case of tropospheric ozone the context is not static but is the result of a historical process that has shaped much of western society over the last century or so (Lowe, 1992). If change in this behavioural pathway of ever increasing dependence on private road transport[12] is to be achieved the importance of that behaviour to the individual needs to be understood both qualitatively and quantitatively. Policies aimed at changing behaviour need to be applicable and acceptable to the population at which they are aimed (chapter 1), in this case that of the car driving public.

Present approaches aimed at encouraging alternative behaviour have a major problem in that they tend to appeal to one aspect of the utility derived from private car use, i.e. that of the perceived low cost which this form of transport has compared to others (e.g. Department of the Environment and Department of Transport, 1993; Barde, Johanes et al., 1994). This feature of utility has dominated the economic and political culture for the last 20 years or so (refer to chapter 4) but suffers from many of the problems outlined in section 2.1.1: The approach neglects other aspects of utility derived from private car use. It will be shown that other aspects of well-being derived from private car use include such features as flexibility and security and these are considered by car drivers as of equal or more importance that any perceived low costs. The use of financial disincentives to coerce the public away from using the car without available and applicable alternatives to mitigate this loss (O'Riorden, 1996) of affordable access to the motor-car may well result in a great deal of resentment. This in turn may cause political disfavour or in some cases even a rise in perceived criminality as the value set of the population becomes distant from the policies being formulated (North, 1984).

Furthermore, like any other cultural aspects, these value sets attached to the use of private transport activity will be shown to vary along spatial, temporal, social, and occupational parameters. For air quality management to be effective, these features need to be identified and recognised within the policy framework (O'Riordan, 1995; Ahuja, 1996; O'Riordan, 1996).

[12] This is the stated aim in recent policy documents (Department of the Environment and Department of Transport 1993; DoE 1994 ; DoE 1995a; DoE 1995b; DoE 11/1996 1996).

Table 3-2: the varied issues and concerns in air quality management (participants were asked to complete a "how to".. sentence. Responses are classed within three different catagoires, beyond this the columns are not connected, all quotes are ad verbatum).

Social	Political	Technical
Change people's behaviour	Pay for this	Quantify the problem of exposure
Cultivate more rational behaviour	Link air quality to other strategies	Apply life cycle costing honestly
Define public expectations	Best involve health practitioners	Best use new technology
Distinguish between wants and needs	Convince central government to manage aq rather than just local authorities	Collect data to substantiate concerns
Encourage active participation	Get central government to take risks	Deal with vested interests
Encourage involvement of shareholders	Get organisations to work together	Determine if health standards are correct
Encourage long term thinking	Get political support for long term projects	Discover toxin levels
Encourage more honest marketing	Incorporate reviews	Encourage stick and carrot
Encourage regulation of buses and rail	Overcome bureaucratic obstinance	Get vehicle manufacturers to improve engine efficiency
Encourage the delivery of goods	React to scare stories about health	Harness solar energy
Encourage working from home	Reduce complex issues to simple actions	Stop pollution beyond 2005
Ensure communication with 100% of the population	Remedy upwards	Identify what causes, cause what problems and how these should be answered
Get people interested	Shorten the time scale	Improve access to the town centre
Get the motor industry to reduce production	Stop local hands being tied by central government	Interpret data
Encourage community heating schemes	Work with other areas	Measure the relationship between inside and outdoor pollution levels
Maintain focus on sensitive groups	Agree what action should be taken	Not restrict development
Make children aware of problems	Change education practices	Predict what the future will bring
Not discriminate against the elder village	Get political acceptance of anything that opposes the status quo	Prioritise pollutants
Promote a realistic public transport structure	Link with other authorities	Publish monitoring data in the press as often as possible
Promote a safe environment for cycling and walking	Take the message to industry	Quantify effects on more sensitive groups
Publish meaningful data		Regenerate town centres
Persuade people to accept lower standards of comfort		Satisfy increased demand for accessibility

This study proposes a need to recognise that life-styles highly reliant on the use of the motor-car have become a feature of modern UK living. The reliance on this form of transport, like all behavioural strategies is not only a facilitator in societal behaviour, but also constrains the individual in a particular behavioural pathway (see Chapter 2.1.4). Removal of this access to private transport without any form of substitute suitable to the individual may lead to a disenfranchisement between individuals and their ability to realise their ambitions within their general environment. From this point of view it can be seen that equity in a policy aimed at restricting the use of the private motor car is important, not only from a basic sense of liberal morality, but also to avoid the problems of inapplicability or unacceptability that may lead to poor take-up of expensive investments[13] or wide scale resentment that can threaten the stability of the policy or policy institution.

3.8.4 Thesis Proposition: The Need to Reconcile the Strategic Gap in Environmental Management, An Example Of Tropospheric Ozone.

If one considers the problem of air quality management, one can see that there is a variation in both issues and agendas, not only between the management institutions and the recipient population, but also between different sections of the management institution itself.

What traditionally have been separate and discrete departments based around different professions (please refer to chapters 4 and 5) with different remits, aims, and value sets, are now being asked to work more closely together, with the aim of achieving the common cause of improving local air quality (DoE, 1997). In a sense this imposes a requirement on local authority departments to disregard their cultural history by imposing new and very different working practices and structures on top of what has been the product of nearly 150 years of institutional evolution.

It will be shown that local air quality management in the UK has evolved from a top-down process formulated at central government level, for tackling localised point sources which were amenable to technical mitigation promoted by financial incentives or disincentives (Chapter 4). The current top-down setting of air quality standards and emphasis on local management defined along administrative boundaries reflects this, and relies more on these past approaches than on approaches suited to a whole new breed of problems presented by the present reliance on the heavy use of the private motor car in the UK.

Managing road transport-derived ozone does not fit easily into any one aspect of the departmentalised institutional framework (Bouwer, 1994) and represents many different problems to many different professions (see chapter 7). That this is the case was illustrated in a recent workshop (Bedford Borough Council Workshop, 17/10/96- see appendix 2) carried out in Bedfordshire. The workshop involved local council members and other officers whose remit falls within transport, economic and air quality management. Participants were asked to consider and suggests important issues related to the control of air qualitity in Bedfordshire. Table 2-1 summarises the

[13] a good example of which has been the Park and Ride schemes, and more recently the overwhelming failure of recent cheap public transport schemes to woo people away from private car use (Air Health Strategy January, 1997).

results. It shows the wide range of issues raised by the participants at the beginning of the workshop and categorises them in terms of technical, social and natural environmental areas of interest.

The nature of both the source behaviour and the reception of ozone means that many different value sets are represented within one activity (Longhurst et al, 1996).

This feature has resulted in modern air quality management becoming recognised as an issue that demands that what have traditionally been discrete professions, must now work together in a more integrated and co-operative manner (DoE 1997). However, chapter 4 will suggest that the departmentalised history of these institutions has resulted in the evolution of what are essentially different sub-cultures in environmental management, with associated values sets and issues which are not always congenial to each other.

However, taking the proposition that people's values and perceptions are formed by the interaction between themselves and their immediate environment, it is likely that each individual who has traditionally worked within this departmental structure has had their opinions, values and working strategy affected by that departmental sub-culture (Bate, 1994; Hofstede, 1994). It will be illustrated that this has produced an internal structure in the institutions responsible for air quality management which has weak linkages and results both within and across the tiers of management in different people approaching the problem in different and often contradictory ways (see chapters 7 and 8)

To this end it will be shown that:

There is an incongruency between the internal culture of the tiered set of institutions aimed at managing environmental resources and the social and biophysical systems within which they sit. This culture that is not responsive enough to its external environment to manage a dispersed, behaviourally derived pollutant which manifest itself as different pollutants in different locations across different administrative boundaries.

The problem of transport-derived ozone being the product of such a wide-spread and common activity does not only affect the way in which the management institutions need to relate to the public, but also brings in a wide range of management issues within the policy making structures. The rather discrete and segregated history in UK administration based on a strong departmental structure is likely to have caused an evolution of what are essentially occupational sub-cultures within the management framework (Bate, 1994). In UK policy formation these intra-organisational sub-cultures tend to be strong and have evolved in isolation of each other, due to strong departmental division in local and central government management (Commission for the European Communities, 1993).

The distancing between decision makers and the public is, as will be shown, illustrated in the present dominance of financial incentives or disincentives in controlling the use of the motor-car. It is suggested that this tool appeals to only one aspect of the utility which people derive from the use of the motor-car, an item of modern society that has come to serve a wide range of personal needs and desires in everyday life. In order to avoid problems of policy unacceptance resulting in possible high policing costs and dissension, policies aimed at weaning the population away from the use of the motor-car need to be accompanied by compensation by way of alternatives which are applicable and acceptable to the population at which they are aimed.

Furthermore it is proposed that since these needs and desires from road transport are the result of value sets that develop within the individual along the cultural parameters of time, space and occupation (each sub-culture also develops along these parameters), that the compensation that will be deemed acceptable and applicable to the population will also vary along these parameters and needs to be designed within these constraints rather than imposed on them. This requires a shift from the present public welfare-based approach to environmental management towards a more participatory approach (McAuslan, 1980).

This leads us to the second proposition, which is that:

There is a strategic gap between the aim of institutions involved in environmental management to effect change in the social system with regards to improving air quality This incongruence is the result of a culture that has traditionally relied on member/stakeholder input into the institutional culture, and neglected the elicitation of inputs into the culture representing the wider social/biophysical environment.

The hypothesis to be broached in this document states that the present institutional or cultural framework in environmental management of the spatially and functionally split departmental approach to policy design and implementation, mixed with a long-standing tradition of public welfare as opposed to public participation (McAuslan, 1980), or what O'Riordan refers to as legitimised public consultation as opposed to legitimate consultation (O'Riordan, 1996), has resulted in a policy process that has become incongruent with the biophysical and social environment in which it sits, or to put it another way, as resulted in a large negative strategic gap[14].

To address this incongruity between organisational culture and the nature of the systems it aims to manage (Harrison, 1989) will require a full understanding not only of the technical aspects of air pollution but a deep understanding of the cause of the problem, in this instance private road transport usage, and its relationships with peoples lives (Lowe, 1992) and the institutions which are needed to manage them. If change in this behaviour is to be achieved then the implicit and explicit way in which this behaviour fits into peoples lives needs to be understood (Bate 1994) in relation not only to the way in which the activity enables their present behaviour within society, but also the way in which their behaviour is constrained if access to the private motor vehicle is withdrawn.

This thesis therefore proposes that the main problem in the management of tropospheric ozone is not technical, or indeed an issue of monitoring and data acquisition (as is the view put forward by the UK National Air Quality Strategy, DoE 1997), but is one of management. The next section of the thesis (part 2) will, using empirical data, explore the proposed gap between the management culture (structure and strategy, section 2.2.2). It will illustrate that there is a general incongruity between

[14] see glossary

the aspirations of this institutional framework and its ability to realise these aspirations. This situation represents a negative strategic gap and therefore supports the call for cultural transformation within that framework.

3.9 Research Exercises

Part 2 of this thesis will demonstrate that the essentially top-down approach of the modern tiered environmental framework mixed with a strong departmental structure, based within the public welfare paradigm, has resulted in a framework that is presently too unresponsive to the changing problems it aims to approach. It will been shown by the use of primary and secondary data that within air quality management there is an incongruity between the social and biophysical issues and the aims and aspirations of air quality management system that need to be approached.

It will also be demonstrated that a major problem is that the aims and strategy of this management system are spatially, temporally and culturally distant to those of the car driving public in any location, and it will be argued that since these informal institutions also show these variations, it is important that decisions are made as close as possible to the population they are most likely to affect to allow for this variation.

To this end the analysis of the problem is separated into a description of the biophysical and social systems concerning the production transport and transformation of this pollutant and is separated into the following chapters:

Chapters 4 & 5 will introduce the present policy-making institutions involved in the management of tropospheric ozone, their historical context and the present nature of the relationships between these institutions themselves and with regards to the general public. These will be reviewed in respect of the constraints they place on strategic management of tropospheric ozone in chapter 8.

Chapter 6 uses secondary data from a variety of sources in the south central region of the UK to illustrate how a regional ozone problem manifests as a series of local issues. Here it is thought the main areas of export are the city of London as well a long range European flows. The main point of reception is the semi-rural and rural areas to the NW.

Chapter 7 is a description of the social values attached to the activity of car use, expressed in wide utility terms. It aims to illustrate the spatial and cultural parameters of this activity and argues that these values change quantitatively and qualitatively in different localities and this has a distinct relevance to the level at which compensatory provision is designed and implemented.

The latter part of the thesis will review the recently published policy framework and the actions through which this framework is being put into practice at the national and local levels. Concentrating on the local tier, it will also use primary interview data to show the variation in the values and issues present within the management organisation and local population. The data will be used to argue that there is a need for a shift from the segregated, top down and public welfare based approach of the present Air Quality Management to a more flexible approach based on the concepts of networking and communication both within the management framework and between decision makers and the general public.

4. The Tiered Environmental Management Framework in the UK

This chapter will review the institutional arrangement for the management of air pollution in the UK. Specifically it will consider the history of management and the nature of the relationships between the different institutions involved at the same and differing spatial levels as well as between these institutions and the general public.

The more in-depth review into the actual policy and practice concerning transport derived ozone management is covered in the following chapter. This chapter restricts itself to introducing institutions and maps their option space with regard to the control of the different aspects of the pollutant.

Part 3 of the thesis will illustrate the incongruities between these present options spaces and will support the argument for a new approach to communication and goal formulation in air quality management based on managing conflict in a socially relevant and responsive manner.

The policy context for the abatement of transport derived tropospheric ozone is at present very unclear, since until recently it was expected to fall under legislation concerning the local management of air quality within government and EU set targets. However, as a result of newly perceived difficulties (both political and technically based) it has, at present, been left out of the new governmental legislation concerning road traffic derived pollutants (Air Health Strategy, 1996b; DoE 1977). In spite of this, standards for tropospheric ozone do appear in recent legislation along with general aims for its management. Targets are also planned for as a daughter directive under the European Air Quality Directive, to be introduced in 1998.

When considering the management of tropospheric ozone one really needs to consider how the precursors are managed. At present there are responsibilities, aims, and approaches being implemented and refined for the management of these precursor pollutants within an evolving national, international and European framework of agreements and requirements.

However, while the management of ground level ozone may equate with the management of these precursors, it must be remembered that the aims of management are different and often the approach needed is contrary to that surrounding the management of precursors for their own sake (see chapter 2). Furthermore, unlike ground level ozone, NOx has strong non-local issues attached to it such as acid precipitation and a potential for global warming (NSCA, 1995). The result is that the management of tropospheric ozone rests in an elaborate framework involving many tiers of government, from local to international. Furthermore, this framework is influenced by an intricate web of agreement and legislation, both between these tiers and often within each tier. This structure needs to be accounted for when studying the issue.

4.1 The International Framework

The international framework for the management of air pollution essentially takes the form of a series of agreed principles and aims. While influencing the framework within which management strategies for air pollution are adopted, these agreements are not legally binding. For the purpose of this study they are dealt with in less depth than the agreements and legislation in the national and local tiers of management.

The most comprehensive statement of international principles concerning the global management of air pollution was drawn up at the 1992 United Nations Conference on the Environment and Development (NSCA, 1996,.DoE, 1996). While little in the way of hard commitment to environmental targets and goals was achieved at this conference (Royal Institute of International Affairs 1995), the series of agreements for environmental management that was established included principles for international co-operation, spatial strategies at different levels, techniques and research agendas. These are shown in Table 4.1.

Table 4-1: International agreements standing after the 1992 UNCED

States should participate in and encourage public awareness.
Environmental measures addressing trans-boundary pollution should be based on international consensus.
States should develop national law regarding liability and compensation for the victims of pollution and other environmental damage.
States should co-operate, in a determined manner, to develop international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control, to areas beyond their jurisdiction.
States should effectively co-operate to discourage or prevent the relocation to other states of any activities and/or substances that cause severe environmental degradation or are found to be harmful to human health.
States should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.
Environmental issues are best handled at the relevant level with the participation of all those concerned.
Local communities should have a vital role in environment and development because they are holders of unique knowledge of the locality and traditional practices.
States should encourage public awareness and participation by making information widely available. At the national level each individual should have appropriate access to information concerning the environment...and the opportunity to partake in the decision making process. Effective access to judicial and administrative proceedings, including redress and remedy shall be provided.
States shall enact effective environmental legislation so that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply.
Strategies should be developed and applied that utilize the best available means of the technologies applied.
The precautionary approach shall be widely applied by states according to their capabilities.
Transport systems should be developed which are safer, cost effective, more efficient and less polluting. That information base on environmental issues of the transport system should be developed.
There is a need for better scientific knowledge of the linkages between atmospheric processes, human activities and biogeographical processes. An integrated approach to transport, human settlement patterns and environmental planning should be developed.

In addition to these principles the conference and policies also stressed the need for the establishment of databases on environmental quality and government policies to maintain it, with particular reference to climate change.

In addition to the main international principles described above there are two main agreements that concern pollutants relevant to ground level ozone. These are the NOx protocol, signed in 1988 at Sofia and implemented in 1991, and the VOC protocol signed in Geneva in 1991, both of which came into effect for each signatory ninety days after their ratification. The two protocols emerged from the *Convention on Long Range Transboundary Air Pollution* in 1989 under the auspices of the UN Economic Commission (representing US and European governments). Both protocols have been ratified by the UK and the EU.

The NOx protocol was intended to freeze emissions by signatory states at 1987 baseline conditions by 1994. The method by which this was to be achieved is stated as

> *reductions in emissions of (..) nitrogen oxides will be negotiated taking into account the best available scientific and technical developments ... and internationally accepted critical loads. (NSCA, 1995).*

Critical loads are defined as the level of pollutant which a receptor, e.g. human, plant or ecosystem, can tolerate without suffering long term health effects according to current knowledge. The main area of activity under this protocol is a critical load mapping of NOx levels which is being undertaken in the European Union (EU) by the European Evaluation and Monitoring Programme. The main issue surrounding NOx within this protocol is the role the pollution plays in the production of acid precipitation and eutrophication of waterways as well as its role in photochemical smog (which was of growing concern in this period in the United States). Most signatory states, including the United Kingdom which is a significant exporter of NOx (DoE, 1996), have failed to meet these targets (Royal Institute of International Affairs 1995; NSCA, 1996).

The VOC Protocol was ratified by the UK in June 1994 and obliges signatories to secure a 30% reduction in their VOC emissions by 1999 using a year between 1984 and 1990 as a baseline.[1] Other Obligations include (NSCA, 1995):

After two years:

- to apply national or international emission standards to new sources of VOCs, taking account of guidance on control technologies given in the protocol;
- to apply national or international measures to products that contain solvents and produce the use of solvents with a low or nil VOC content.

After five years:

- to apply economically feasible best technology to existing statutory sources in those areas where ozone standards are exceeded or transboundary fluxes originate;
- to implement techniques to reduce VOC emissions from petrol distribution and motor vehicle refuelling, and to reduce the volatility of petrol.

A directive concerning the latter parts of the protocol as applied to Europe is currently being finalised.

[1] The particular year for baseline exceedance is to be decided at the discretion of the national government.

4.2 The European Union

The aim of the European Union is stated to be to "bring about the merging of essential economic interests" (CEC, 1992) of the member countries, through the establishment and maintenance of a common market that eliminates all barriers to the movement of persons, goods, services and capital, and the adoption of common policies. As well as the adoption of certain social and economic objectives, political integration is regarded as the ultimate aim (Schiavone, 1986).

The basis of European environmental legislation is laid down in Article 100a of the Single European Act which states that the criteria for environmental protection within the European Union shall conform to the following principles (CEC, 1992a):

i) The Council shall, acting by qualified majority on a proposal from the Commission in co-operation with the EP and ESC, adopt measures for the approximation of decisions laid down by law, regulation or administrative action in member states.

ii) Commission proposals concerning health, safety, and environmental protection will take as a base line, a high standard of protection. Action by the community shall be based on the principles of preventative action, environmental damage should be rectified at source, and the polluter should pay.

iii) In preparing its action relating to the environment, the EC shall take account of:

- available scientific and technical data
- environmental conditions in the various regions of the community
- potential benefits and cost of actions or lack of action
- economic and social development of the community as a whole and balanced development of its regions.

iv) The community shall take action relating to the environment to the extent to which the objectives in paragraph "i" can be obtained at a better level than that of the individual member states, without prejudice to certain measures of a community nature, member states shall finance and implement other measures.

The stated aim of environmental policy within the European Union is to harmonise constraints placed on industry through the implementation of environmental standards throughout the European community, while protecting the health of the natural environment and human beings. The central approach to policy design is based within the cost benefit approach to environmental protection (CEC, 1992). The tool for implementing this legislation into national law is that of the directive which requires member states to draw up and implement national legislation aimed at achieving the aims of the directive, but leaves open to the discretion of the member states the approach taken through national legislation (Axelrod, 1994).

The role of the directive can therefore be seen to be one of regulatory control aimed at ensuring that member states in the European Union conform to set minimum standards. However, the imposition of these standards is not a top-down relationship, and member states have a powerful influence on the form and time-period within which these standards are drawn up through the concept of subsidiarity. This is implemented by the co-operation procedure that has evolved as a result of long standing attempts to form a compromise between the wishes and interests of the European Commission (representing European corporate interests) and those of the Council of Ministers (representing individual members interests).

4.2.1 Subsidiarity and the European Co-operation procedure

Since the signing of the Single European Act and its incorporation into EU law by the ratification of the Maastricht Treaty, the process of formulating directives has been carried out within the Co-operation Procedure (Figure 4.1), intended to extend the power of the European Parliament and remove the sweeping rights of veto by individual representatives to the Commission (Linter and Mazey, 1991).

Within the co-operation procedure, proposals are drawn up by the Commission usually at the suggestion of the Council of Ministers, the European Parliament or by petition from a member state. The proposal is then passed to the Social and Economic Committee for opinion where it is often modified and passed back to the Commission. After acceptance by the EU it is passed to the Council of Ministers where it is considered by COREPER (the EU ambassadors forum, and the first tier of discussion within the Council of Ministers), where it is debated and a common position is adopted by a qualified majority. If the decision is particularly difficult for one or more member states it is often debated within higher tiers of the council (occupied by the Ministers of the Member states representing the sectors affected by the proposal). If the proposal is very controversial and agreement cannot be reached at this level then the decision is passed to the Council of Ministers (see below). After the Council has reached a common position the proposal then enters its second stage. If no common position is reached then the proposal may be rejected.

On entering the second reading. the proposal is resubmitted to the European Parliament where the parliament has the right of amendment. Here the parliament may do one of three things:

- Parliament either accepts the Council's position or allows a time limit of three months to pass in which case the Council adopts its position and passes this into Union law.
- Parliament may reject the Councils position. In this case the proposal must be referred back to the Council who may still adopt the position but only by unanimity. However, the process of achieving unanimity is difficult and often produces a deadlock that can suppress proposals altogether (Brochardt, 1991) Therefore this approach is rarely used by Parliament, which instead often follows the next course of action.
- Parliament may propose amendments to the common position. These must then be endorsed by the Commission. If this happens, the amendments may then be adopted by qualified majority within the Council. However, if the Commission does not endorse the amendments then they must be accepted by the Council on the basis of unanimity.

While the Single European Act was intended to, with some success, confer greater powers on the EU parliament, it is still very difficult for Parliament to promote its opinion in the face of conflict from the Council. If Parliament's position is supported by the Commission then it is possible to exert influence on the Council in such a way as to weaken the position of individual member states. However, even in this situation Council can still block legislation and proposals by vetoing the Commission and Parliament as a group, and therefore blocking any legislation. Therefore while the co-operation procedure can be seen as a move away from the power conferred on the Council whose role it is to represent the interests of member governments, this body is still perhaps the most influential in deciding the form and type of European legislation. This case can be argued further when one examines the less formal aspects of the decision making process within the European Union.

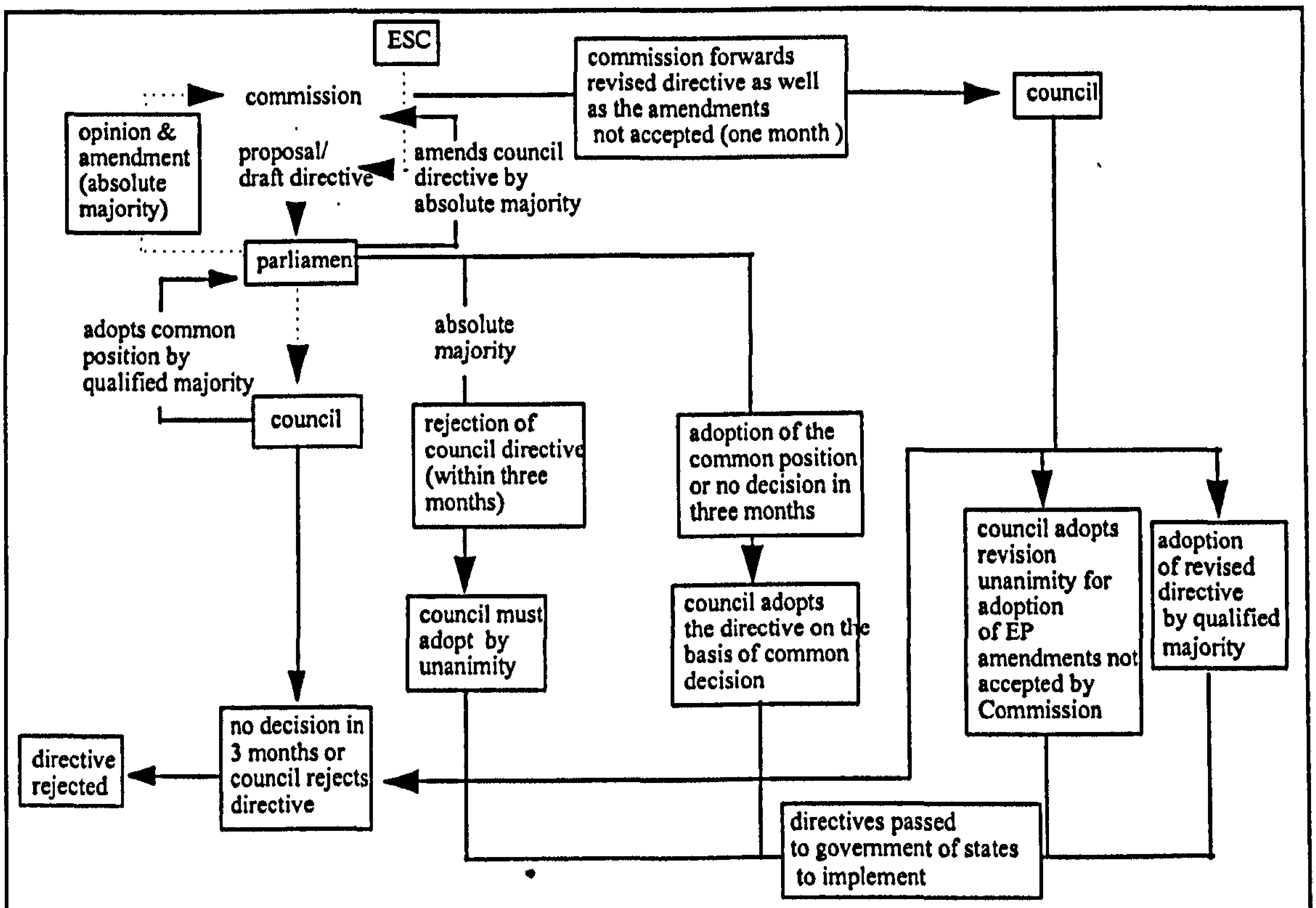

Figure 4-1: A Schematic of the co-operation procedure in EU decision making

Policy formulation within the Commission is taken up by the Directorate concerned in consultation with other Directorates, indeed since 1987 it has been a duty that all Directorate-Generals incorporate environmental issues within the policy formulating process.

The motivation for this action may come in the form of promoting one nation's wishes on environmental standards or actions, or restricting one nation's standards that may cause disruption in the "level playing field". In this way the Commission act as a mediator between member states as well as between the interests of environmental legislation and economic growth. Within the role of environmentally related legislation the Commission has an increasingly active role (CEC, 1993) especially in a situation where one member state conflicts with the imposition of environmental legislation (as is often the case at present) due to interests resulting from its industry and trade.

4.2.2 The European Air Quality Management Framework

This framework translates into a collection of technically based emission limits for motor vehicle exhaust systems based on the emission of single pollutants and a framework directive for the introduction of air quality standards that essentially establishes a baseline for European member states in terms of ambient air quality in respect of a number of pollutants, including NO_x and tropospheric ozone. The standards are presently evolving through negotiation between the European Community and member states and are reviewed in chapter 4, along with research into national and local management policy and techniques.

4.3 The Framework for Air Quality Management in the United Kingdom.

The remit of the management of air pollution within the UK falls on two levels of government and a regionally separated national quango (quasi-autonomous national government organisation), the Environment Agency. However, with road transport derived air pollution, one must consider not only those organisations that are concerned directly with air pollution, but also those whose remit falls on road transport, land-use and economic development. Thus the framework for the management of air quality in the United Kingdom is fragmented between interest groups, legislators and affected parties who can influence how transport derived air pollutants are managed (see Figure 4-2).

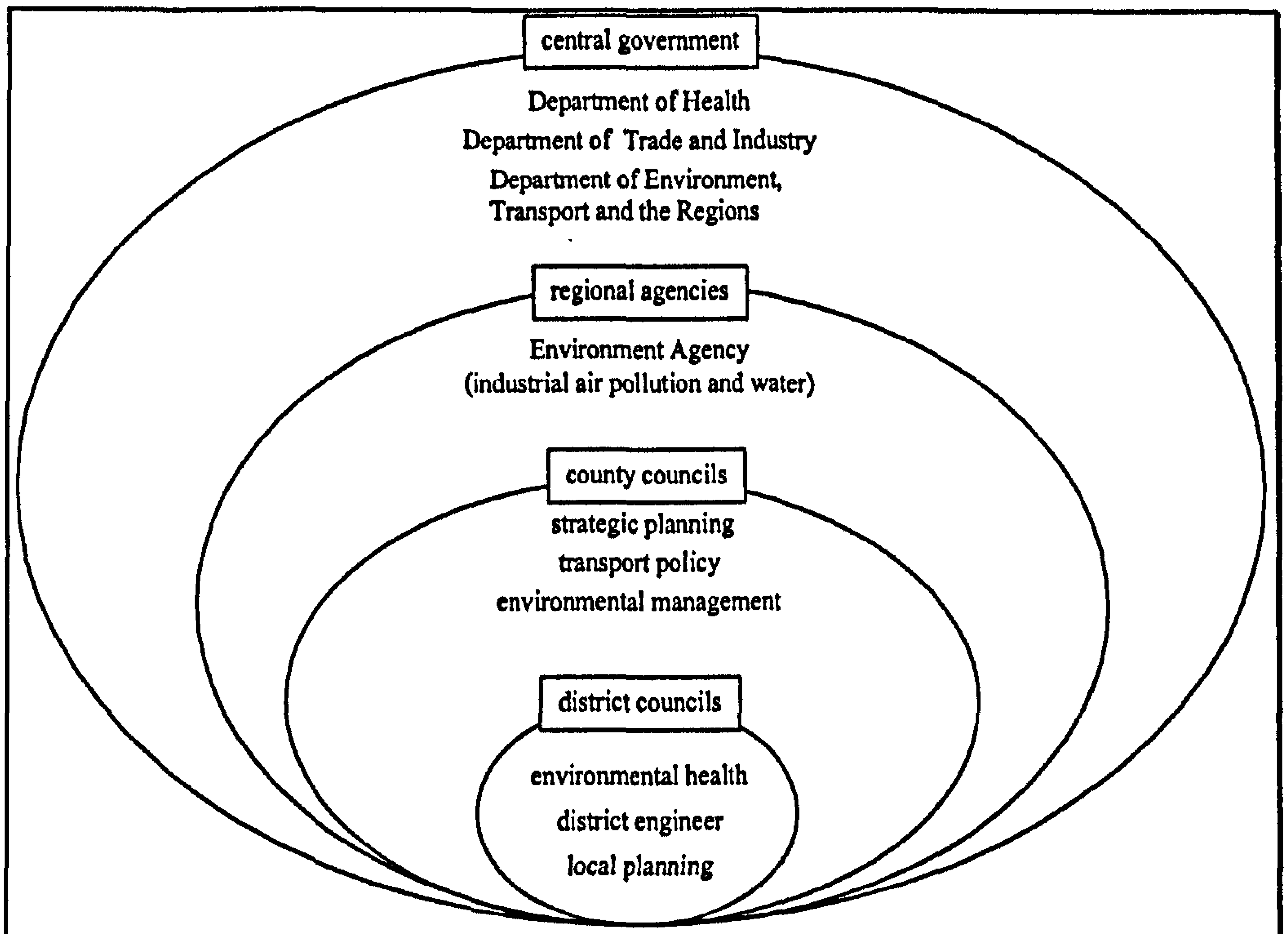

Figure 4-2: A selected group of interest parties in air quality management.

This framework has evolved from a long turbulent history of locally enforced common law and specifically enforced national legislation. Both have influenced the approach, structure and culture of present air quality management (Sperling, 1984; Bate, 1994). Therefore before investigating the present framework, it is useful to review this historical development.

4.3.1 A Brief History of Air Pollution Legislation

Although health impacts of air pollution are often viewed as a modern phenomenon, they are not . Indeed in ancient Rome pollution from smoke was so severe that the Emperor Tiberius was prescribed by his physician to move from the city to the countryside to avoid the stench of the air. In Saxon Britain it has been shown that indoor pollution from the burning of wood fires mixed with poor ventilation was a major cause of disease. In the UK attempts to control air pollution in the 13th can be accredited for producing the first legislation specifically aimed at controlling environmental pollution when by Royal assent in 1273 the King issued an edict against the burning of sea coal within London City limits

(NSCA; 1995). It is reported that a man was executed in 1310 for ignoring this piece of legislation (Ratcliffe, 1992).

The legislative management of air pollution for most of history has however, rested on the control of nuisance under common law, with the emphasis firmly placed on the protection of the health and well-being of the individual rather than that on protection of the air (Ashby and Anderson, 1981). However, with the advent of the industrial revolution coal burning in cities became widespread and heavy. The nuisance of air pollution became a public menace, and as early as 1662 pollution from smog was established as being a direct threat to public health.

By the 18th century concern about smoke related air pollution was so great as to stimulate the development of devices aimed at feeding engine coal back into the machinery, and in some areas the local constabulary had the power to enforce their use. However, in spite of what were essentially the first ever emission controls air pollution worsened due to the quickly growing number of chimneys.

In 1820 concern was high over the effects smoke was having on both the health of the city population and on the city itself. Air pollution was recognised as having social impacts in that it was making large areas of the city uncomfortable to inhabit, leading to the migration of the wealthier residents to more rural locations, and thus leading to the emerging notion of inner city decay (Wohl, 1983).

In response to this concern Michael Taylor, an MP for Durham City, proposed a bill aimed at compelling operators of steam engines "*to erect them in a manner less prejudicial to public health and comfort*" stressing the use of new technology based on that developed some hundred years earlier. The bill stated that action against non-compliance was still to be taken under common law as a nuisance. It also stressed the approach of best practical means, which later became a focus for air pollution legislation (Ashby and Anderson, 1981) and received much opposition from operators (and their political representatives) who were concerned that the design of engines and furnaces would be interfered with by the courts and that industrial competitiveness would be impeded. In the event the bill went through in 1842 with wings clipped: many processes were exempt, for example furnaces during stoking. However, it did represent the first tentative steps ever taken to control industrial air pollution on a large scale in a way which is still pertinent today. It also showed for the first time the defences against such legislation (Ashby and Anderson 1981).

In the event the Taylor Bill achieved little due to the restrictions on processes liable for emission control, the difficulty of proving nuisance in the civil court, and the presence of the defence for polluters of showing the application to best practical means (NSCA, 1995). Of these factors the proving of nuisance has been the most problematic for although the correlation between mortality and smoke pollution had been established as early as the 1600s causality, had not. Long working hours, the age of the population affected (usually the old and those with lung related illness), and poverty were seen as responsible for fatalities through tuberculosis, bronchitis and asthma (Ashby and Anderson, 1981). Health effects therefore proved difficult to establish and the bill had to rely on *nuisance*, a subjective term which was often easily defended against by the lawyers representing the rich industrialists (Ashby, 1981).

In response to the poor results of this bill, there emerged what has been described as the first campaign for clean air. It was initiated by the vicar of Rochdale and taken up in parliament by his brother-in-law W.A. MacKinson, who headed a Select Committee into the subject. MacKinson's campaign is interesting not so much for the results it achieved but for the industrialists' defence of the right to pollute that it invoked (Ashby and Anderson, 1981). MacKinson showed that in the late 1800s smoke abatement was an essentially legislative rather than a technical problem. The abatement legislation was too lax and the fines issued were too low to deter the offence (Ashby and Anderson, 1981). The eventual effect of MacKinson's campaign, however, was to heighten concern over the subject both in parliament and in the public eye, and resulted in the passing of a series of bills within the commons. The industrial sector rallied in opposition. The main arguments against a smoke control bill were that it would cause wide-spread unemployment in the industrial North, it would be intrusive on manufactures who were after all the generators of the nations wealth and was premature in light of the present state of knowledge. The effect of such lobbying was essentially to weaken legislative proposals, for example the smoke abatement section of the Public Health Bill (1848) through the addition of such phrases as 'if practicable' and by the introduction of a list of exempted processes. It was eventually dropped in the House of Commons. Although reinstated in the House of Lords it was again defeated in the Commons and with this defeat came the suppression of all other major legislation aimed at curtailing smoke pollution.

The main result of the campaign, was the creation and consolidation of a powerful industrial lobby that successfully defeated six more proposals on smoke abatement and in this period only one bill, the 1847 Town Improvement Clauses Bill, was passed. This was a permissive bill that allowed local authorities to harmonise legislation if they wished, it had no mandatory powers.

Although smoke pollution during this period was of public concern, the failure to secure any significant legislation during this period has been explained as follows (Ashby and Anderson 1981):

- no one had proved that smoke was a direct health hazard
- there was no ideal device for smoke abatement
- smoke was too low in the public priority of concern
- the access to legal representation of the industrial giants was much greater than that of any potential plaintiff in common law.

However, MacKinson's campaign did have a profound effect on public attitudes and the years of constant pressure raised concern over air pollution which was firmly put on the political agenda. While campaigns for clean air legislation floundered in the face of organised opposition, the increased public concern about air pollution that it instigated did lead to increased action over the issue. This paved the way for what was essentially the first legislation aimed directly at improving air quality, the 1853 Smoke Abatement Act. This Act stated:

> *"Every Furnace within the Metropolitan District* [London] *and every Steam Boat on the Thames between London Bridge and Richmond Bridge shall be fitted with an apparatus for consuming smoke or shall burn coke instead of coal. Penalty twenty pounds for the first conviction and ten pounds for every day the offense is continued after conviction"*

(Public Records Office, 1853)

While the local perspective of the legislation helped to avoid some of the wrath of the powerful northern industrialists, the bill did meet great opposition. Opposition was also avoided through dilution by sub-clauses stating for example *"that to burn their own smoke should not mean all smoke"* (Ashby and Anderson, 1981). However, in spite of these concessions it still took an impassioned speech by the bill's proposer Lord Palmerson (Home Secretary 1852-53), directed at those who were opposing the bill because of self-interest, to achieve a commons vote to accept the bill in principle, after which the act was passed relatively smoothly.

The legislation itself was not restricted to improving the grounds for prosecuting against air pollution as a nuisance in common law but identified excessive emission as a specific offence. However, the bill did omit to identify who was to police and administer the act, an omission that was dealt with after attention had been brought to this by the press and the duty was handed to the local constabulary.

This act, even after it had been passed would have still foundered without the attention of Palmerson, who had to put great pressure on the police to prosecute violators as well as the courts to convict to its full extent (Ashby and Anderson, 1981). This was eventually achieved and the bill did have some effect on London air quality.

4.3.1.1 The Alkali Acts

The previous public health acts were either aimed at a specific locality (i.e. the 1853 Smoke Abatement [Metropolis] Act) or managed by local health boards. These boards, were not compulsory in local government and there was little guidance as to their duties. However, the next stage of legislation was to change this situation radically and provide the UK with what its first body specifically designed to monitor and manage air pollution control legislation, the Alkali Inspectorate.

Despite nearly half a century of campaigning by 1860 atmospheric pollution had brought worsening urban squalor (NSCA, 1995). Discharges from alkali works were producing appalling air pollution that was both deleterious to health and devastating to the countryside (NSCA, 1996). In response to this Lord Derby (Leader of the Opposition in the House of Lords) whose estate was within some five miles of major alkali works (Ashby and Anderson 1981), instigated a House of Lords Committee to look into the problem and formulate legislation aimed at its management. The context of this report was rather delicate in that the milling industries of the North were suffering economic depression due to the interruption of raw cotton supplies by the American Civil War. Therefore, in response to this Lord Derby went to great pains to restrict any legislative proposals purely to alkali works (Ashby and Anderson, 1981). Indeed in the legislation resulting from the committee there was no attempt to control smoke whatsoever (NSCA, 1995) and a speech issued at this time by Derby aimed specifically to put industrial concerns to rest and stated that the committee would examine:

> *"whether legislative measures could be introduced on this subject not only without injury, but with profit to manufactures".*

The findings of the committee were encouraging in that, unlike with the smoke campaigns, the scientific evidence surrounding the effects of substances in alkali discharges was unequivocally demonstrated. Technical solutions were available and easy to install (essentially flue gas treatment processes) and there was evidence that alkali manufacturers actually wanted statutory control in order to prevent the inconvenience of troublesome prosecution while preventing advantage to non-controlling competitors (Ashby and Anderson 1981).

The committee's work culminated in the 1863 Alkali Works Act. This act fell well short of the committees recommendations in that it restricted itself to the control of only one of the major pollutants emanating from alkali production, that of HCl vapour to 95% recondensation of flue gas, and even within this restricted context the Act did not concede to any individual the right to take offenders to court. However, the Act did have one important facet instating:

> *"Enforcement officers should be wholly independent of all local control and removed in as far as possible from all local influence" (Ashby and Anderson 1981).*

The reason for this, it was stressed, was *not* that local authorities could not be trusted, but that it would be difficult for local authorities to be detached from local industry and that it would be difficult for them to recruit the specialist staff needed for carrying out the duties laid down under the Act. This body became the Alkali Inspectorate and was set up under the auspices of the Board of Trade (now the DTi). The act did set two main precedents it established the principle that central government was responsible for the protection of air against pollution from noxious vapours and it set up the dichotomous nature of air quality management between local and national perspectives.

While the act was implemented by the Alkali Inspectorate with great fervour, the restrictions placed on the agency were severe and while the Act can be seen to have achieved its goal of ensuring that every alkali works recondensed 95% of their HCl emissions, it did not achieve its aim of improving air quality. The reasons for this were firstly that the rapid rate of growth within this industry meant that while the emission from each chimney was reduced there was an ever growing number of chimneys, and secondly poor air quality resulting from industrial emissions was not just the caused by HCl but also by H_2SO_4. The Alkali Inspectorate, which was still in a probationary period, therefore faced a dilemma. On one side it was heavily constrained by the act, and on the other was peppered by complaints from the public concerned about, and with raised expectations of, air quality. In response to this, the Alkali Inspectorate sought within the framework of the act to expand its remit. The chief inspector at the time commented that the spirit of the Act rather than the letter should be employed (Ashby and Anderson, 1981) and that the Inspectorate should be seen as an embryo of a system of control which would ultimately embrace all pollution of air and water (this vision has recently been fulfilled with regard to industrial emissions more than 100 years later by the establishment of the Environmental Agency). In this respect, although the agency had no powers to control other pollutants that HCl, it routinely carried out research into the amount of other vapours emitted.

In the 1872 Public Health Act the Alkali Inspectorate was given a permanent mandate and transferred to the Board of Local Government (later to be incorporated into the Department of the Environment). However the mandate was not extended beyond the Control of HCl from alkali works.

In the years preceding this act the number of complaints from the general public to the Local Government Board regarding the failure to improve air quality increased, despite the act being considered as having had a "significant success" in achieving its aims (NSCA, 1995). The complaints came from a number of new pressure groups that had arisen as a result of the concerns of landowners in the Northern parts of the country. In response to this the Local Government Board, concerned over its public standing, drafted a new bill. In the event the bill put forward to parliament was less than ambitious and included only three new pieces of legislation, which were:

- It set a standard of 0.2 grains per cubic foot for HCl.
- It included only one more process, i.e. that of copper production by the wet smelting technique (another significant producer of HCl).
- It stated that the owners of every alkali works shall use the 'Best Practical Means within a reasonable cost', for preventing discharge of all noxious vapours arising from such work.

However cautious this bill was, it can be seen to have had two important and long lasting effects on the history of air pollution legislation in that it set the first quantified air quality standard and established the concept of best practical means. Furthermore, under the auspices of this act and the application of it to pollution control, the concept of Best Practical Means shifted emphasis from being the main defence of polluters to being a powerful weapon in the arsenal of pollution control legislation (NSCA, 1995).

4.3.1.2 The Best Practical Means

During its passage through the House of Lords the phrase "*best practical means not entailing unreasonable cost*" was converted to 'best practical means'. Despite this, when the second Alkali Act came into existence the phrase 'best practical means' was met with some consternation by the Alkali Inspectorate since the principle had often been a secure defence in litigation against smoke control. However, the act laid down guidelines for this principle and with careful attention from the inspectorate it became a powerful tool for those who would wish to control pollution (Ashby and Anderson, 1981).

The essential elements of this principle have evolved under the Alkali Inspectorate and more recently Her Majesty's Inspectorate of Pollution and the Pollution Inspectorate to contain the following elements (NSCA, 1996):

- No emissions can be tolerated that constitute a recognised health hazard, either short or long term;
- emissions in terms of both concentration and mass, have to be reduced to the lowest practical amount taking into account local conditions and circumstances, the current state of knowledge of control technology, the effects of the substances emitted, financial considerations and the means to be employed;
- having secured the minimum practical emission standards, the height of the discharge should be arranged so that the residual pollutant should be rendered harmless by dispersion and dilution.

The fact that this principle became a weapon for protection rather than defence can be seen to be a result of the existence of a funded and research-based pollution inspectorate which has constantly been able to identify techniques for application within this principle and communicate and promote these techniques to the applicable industries. Indeed, it is in this educational role that the alkali inspectorate and its successors have been most productive (Ashby and Anderson, 1981). Furthermore, in the light of the availability of this information it has become harder for industries to claim the best practical means *known* to them were used. However, best practical means are technical standards rather than health effects standards or an attempt to set limits with regard to environmental protection, and as such in no way restricts the growth in the number of potentially polluting industries.

4.3.1.3 The End of the 19th Century

The eighteenth century saw the first specific air quality legislation and standards, and established many of the working practices in air quality management that are apparent today, including the approach of setting standards and enforcing BPM (now BATNEEC) for emission controls. The approach taken by the first Chief Inspector of the Alkali Board, Robert Smith, along with four sub-inspectors, was to work closely with the industrialists to convince them that improved pollution control was in their own economic interests. This established a culture of professional and centralised inspection which has continued to the present day, and provided a role for qualified scientific experts, so that by 1876 most alkali works were employing their own chemists to help them comply with the acts and to find profitable uses for their waste products. This can be seen to be the first notion in the concept of sustainable development (Wohl, 1983).

The development of the UK approach to air quality management throughout the 19th century can be seen as follows:

- a split between centralised control and inspection of "noxious emissions", and local management of smoke;
- the growth of a professional Inspectorate, working in co-operation with the manufacturers in order to improve pollution control, and employing the flexible formula of "best practicable means"; and perhaps most significantly
- a slow, but steady, shift in public opinion, amid fierce debate, towards the assumption that air quality is a public good which can, and should, be subject to legislative control.

However, of a more ethereal nature, this century also demonstrated the role of public opinion on promoting and enforcing legislation and showed the attitudes to and defences against such legislation by those who benefit from the polluting activity to such legislation. This was illustrated by the distinct regional acceptability of the legislation and showed that local air quality management can be taken up and enforced to different degrees in different areas depending on the economic and structural base of that area.

4.3.1.4 The Great Smog and the Clean Air Act of 1956

Following the Alkali Acts, procedures, however limited, were at least put in place for the management of industrial emissions. A far more taxing, was the issue of domestic smoke production. Although the problem of smoke from coal fires had been recognised for some time, and potential solutions in the form of improved domestic stoves were technologically feasible, it was perceived that the control would present severe political problems. Just as the emissions from factories were seen as a symbol of prosperity and a source of national pride, so the "cheery open fire" was regarded as *"the focus of English family life, with which no politician would dare to interfere"* (Ashby & Anderson 1981). The introduction of legislation to control this feature had to wait until the middle of the next century, when a combination of factors created a more suitable climate for change.

The dense fog which enveloped London from the 5th to the 9th December 1952, and to which four thousand deaths were eventually attributed, is credited with being the trigger which precipitated the 1956 Clean Air Act, through whose provisions local authorities were empowered to declare part or all of their district a 'smoke control area'. However, implementation varied greatly between different areas. While progress in Greater London was so significant that Hall could claim in 1975 that there had been no smogs since 1962, local authorities in coal mining areas were, in the 1960s, more concerned with the mining interests and the future of the industry in their areas. Local grants for changing heating systems were introduced and taken up to varying degrees and the designation and establishment of smoke control areas was carried out with differing enthusiasm (Ashby and Anderson, 1981). Nevertheless, the 1956 Clean Air Act is regarded as having been successful in reducing smoke and smog.

This legislation cannot be seen out of context with the technical development occurring in the 1950s and perhaps some of the improvement in terms of air quality may have resulted purely because of these technological changes, such as the discovery of natural gas in the North Sea, the development of gas and electric powered domestic heating systems and the phasing out of steam locomotion. In any event, without this development of technology in it is unlikely that the acts would have been proposed in the form that they were or would have achieved their aims; illustrating the close coevolution of technology and policy development in the history of air quality management. Ironically, one of the great reductions in coal burning was the replacement of the steam engine with the use of the motor-car and it is this last development that has lead to many of the contemporary problems in air quality management.

The management structures set up under the Alkali Acts continue to influence the management of pollution from industrial processes. Under the Environmental Protection Act of 1990, a framework for a system of integrated pollution control was established. This had the following features:

- Control of pollution from industrial processes was divided between the local authorities and the centrally controlled "Her Majesty's Inspectorate of Pollution" (HMIP), now the environment agency (Murley, 1994);
- Releases of pollution to the air by all prescribed processes were to be minimised by means of, Best Available Techniques Not Entailing Excessive Cost (BATNEEC) a direct descendent of the Best Practicable Means (BPM) formula adopted by the Alkali Board in 1874.

4.3.2 The Management Framework of Air Quality In the UK - Structure

There are two distinct levels of government concerned with air quality in the United Kingdom: the Local Authorities and Central Government. Both are elected authorities on a first-passed-the-post electoral system of regional representation, and are subject to elections at intervals of about four years but often at different times (and often reflect a temporally changing political geography).

Of these levels, it is central government which is at present the most influential part of this framework in designing and directing environmental management. However, it has been said that due to the segregation of environmental responsibility between a number of different departments based on sectorial considerations, the UK has, as a whole, no consistent or unified approach to the management of the environment (Ball and Bell 1992; Therivel 1993).

4.3.2.1 Central Government Departments

The UK parliament is typified by having a series of ministries with a remit over one sector of government who are answerable to the ruling cabinet (figure 4.3) and is typified by a strong interplay of powers between these ministries (Commission for the European Communities 1993). At the central government level, the two-party nature of UK politics essentially means that policy accepted by the cabinet is often passed through parliament with little contestment (Ball and Bell 1992).

Traditionally the central government department with the main remit for environmental matters is the Department of the Environment (DoE). However it is also widely recognised that the other departments have great influence on environmental policy and action pertaining to their sector (Ball and Bell, 1992).

In recent months the DoE has merged with the Department of Transport to form the Department of Environment, Transport and the Regions, while now occupying the same building at Marshem Street in London. The departments have maintained their discreet functions and identity, so will be dealt with separately.

The Department of the Environment (DoE) was constructed from the Ministries of Housing and Local Government, Public Buildings and Works, and Transport in 1970. It is the main central governmental organisation with a remit for environmental matters of pollution and development. The department consists of four ministries, with its legislative and administrative powers concentrated into one office, the Secretary of State (SoS). While the DoE has the main responsibility for what are perceived to be environmental matters in central government, with wide ranging powers to consider the direction of development policy and funding, its powers are far from comprehensive for the following reasons (Ball and Bell 1992; Ratcliffe 1992):

- It is not the only part of government that sets policy concerning the environment, and other ministries exert major power within their own remit;
- It has very few operational powers relating to environmental protection; and
- It is not just restricted to the one remit of environmental matters, but has a wide portfolio including local government finance (which is under direct influence of the treasury); the water industries, and sport and recreation.

Furthermore, the structure and function of the DoE can be seen to be very open to top down political control due to the nature of the electoral system in the UK (Floyd, 1987). This structure allows UK environmental law to be strongly influenced by the ruling political ideology of the time, an influence which occurs through direct law making, the appointment of key personnel in regulatory positions (e.g. the Environment Agency; see below), and the discretionary use of powers for licensing processes and using powers of appeal (Ball and Bell, 1992). The detailed structure of the directors under the umbrella of the DoE is shown in Figure 4.4.

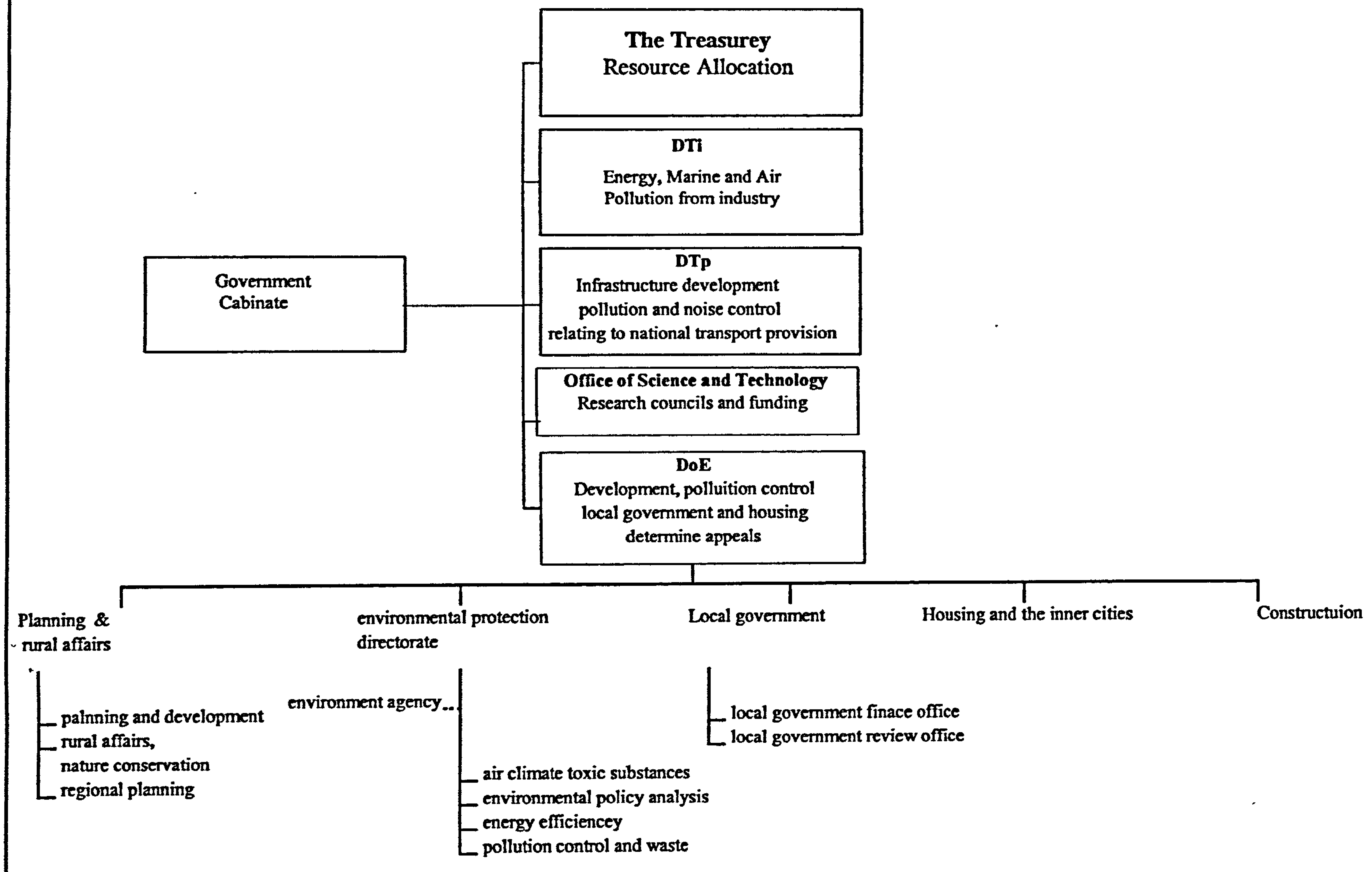

Figure 4.4: Organisational set-up of some of the main central government departments and sub-departments that influence the implementation and design of air quality policy

The DTP is the central government ministry responsible for national transport policy, including setting the budget for, and construction of national transport infra-structure provision of motor-ways and trunk roads (under the auspices of the Highways Agency). It is also to a great extent responsible for national policy aimed at reducing the environmental impact of trunk roads and motor-ways, including the impact of air pollution. It is a semiautonomous department within the remit of the general cabinet and has great influence on local authority transport policy and management, not least since it is this department that is responsible for the main structural skeleton of the country's road system. The Department has control over the monitoring and analytical techniques used in its own environmental impact assessments (under a 1988 amendment of the 1980 Highway's Act), which are essentially project based activities (DTP, 1994), which have been criticised for their lack of co-ordination (Therivel, 1993).

The most influential of the other government departments when considering road transport derived air pollution strategy in the UK are the Treasury and the Department of Trade and Industry (DTi).

The Department of Trade and Industry (DTi) is significant in that it has great influence on industrial practices and legislation. The impact that this department has on air pollution policy has been clearly shown recently in the delay and modification of standards this department has secured with regard to the implementation of UK legislation concerning the VOC protocol (Air Health Strategy; March 1996b).

The Treasury is the major resource allocator and provider, it is also the office where taxation policies are set and it exerts powerful influence on the other departments (Commission for the European Communities 1993). The influence of treasury control over the last twenty years has been strong and it has recently been noted that this department now exerts almost total power over the agendas and approaches of other government departments including the Department of the Environment, Transport, and the Regions (Burke, 1997). This situation has been identified as resulting in a situation where the primary aim of most central government policy is to develop strategies around the least cost approach and the dominance which cost-benefit analysis has in environmental policy design and implementation (Air Health Strategy November 1996; Air Health Strategy September 1996).

Alongside these departments exists another organisation which recently came into being, the Environment Agency (EA). This has an altogether different structure in that it was set up to be autonomous and independent from the government (although, the legislative framework and appointments at senior level are controlled by the DoE). It was created by the 1995 Environment Act (part I) and came into being on April 1st 1996. The setting up of the agency essentially involved a merging of the National Rivers Authority (NRA) and Her Majesty's Inspectorate of Pollution (HMIP), and it is therefore responsible for the regulation and enforcement of the 1993 Water Resources Act and the 1990 Environmental Protection Act (it also absorbed some responsibilities from the Local Authorities).

The EA is a non-departmental body separated into eight regions of England and Wales defined by river catchment areas using district boundaries where possible (NSCA, 1996). Its executive body is appointed by the Secretary of State and has the following responsibilities:

1. waste management licensing;

2. authorisations and licenses of emissions into the atmosphere;
3. monitoring environmental conditions; and
4. giving guidance to industry.

Other than having *regard* to local authority air quality management plans (DoE 1996), the role of the agency with respect to the UK Air Quality Strategy and the 1995 Environment Act (part IV) is uncertain. However, the Agency has stated that it will avoid issues of public health from air pollution and will concentrate on grade "A" industrial processes and will avoid interfering with local authority air quality management plans, but would consider a co-ordination role in the latter (Air Health Strategy February; 1996a; Air Health Strategy; March 1996a).

The policies emanating from this Central Government can be divided into two groups: emission standards to promote the use of BATNEEC within the motor industry at the national levels in line with European policy (Linter and Mazey, 1991) and the designation of a UK set of guidelines and a strategy laying out the role of local government in attaining these. These policies are discussed in-depth in the following chapter.

4.3.3 The Local Authorities

The second level of government in the UK consists of the local authorities which are affected by two major pieces of legislation: the 1990 Environmental Protection Act which is essentially aimed at point source polluters (NSCA, 1996), and the 1995 Environment Act (Part IV) that is more concerned with road transport derived pollutants (ENDS, 1996).

Local Government in the United Kingdom has evolved from a chaotic collection of local parishes and overlapping authorities of different sizes and wealth, a situation described in 1885 as:

> *"a chaos of areas, a chaos of franchises, and a chaos of rates"*
>
> *(Rathbone and Pell, 1885)*

Both local taxation and methods of election were inconsistent and unified policy in even small areas was difficult to establish. For this reason the situation was radically reformed by the Local Government Acts of 1888 and 1894, to form what was essentially the two tier system of county councils (in the former act) and borough councils (in the latter) of today. The structure of the county councils was essentially formulated around the committee system reflecting the limited scope of the duties the early authorities had to manage (Maud Report on Local Government, 1967). However, due to an increase in the scope and detail required in modern administration structure, this committee system has evolved into a complex structure in which elected councillors carry out their duties supported by permanent and unelected departments through which professional officers perform executive tasks designed around a sectoral agenda (Knowles, 1971). These departments tend to dominate policy making within their area of expertise rather than supply the specialist advisory function that they where created for (Knowles, 1971).

In the past the structure of local authorities represented a much greater autonomy for the borough authorities than today however, recently however there has been a shift away from this autonomy especially in the development and resource raising powers of the borough authorities. In some instances this shift was to central government and in others towards the county (and county metropolitan) authorities in an attempt to unify approaches over larger areas and better utilise financial resource (Sheeley, 1978). This process has been added to recently by the generation of a series of new unitary authorities in specific areas such as Milton Keynes and Luton.

4.3.3.1 County Authorities

The County Councils were originally set up as highway authorities and have principal control over much of the local transport infrastructure and regulation (Shelly, 1978). They often work in close collaboration with central government on trunk road planning and construction. Although still a central function of the modern county council, the remit of local transport provision has been extended to include regional development planning. The purpose of this function is to provide a co-ordinated development framework for education, health and welfare within which the constituent local authorities must work (Ratcliff, 1989).

The two main roles of the county authorities are to prepare a county's structure plan and its Transport Policy and Programme report (TPP)[2]. The structure plan has two purposes. Firstly it must justify the county's development strategy to the public and Secretary of State and secondly it aims to interpret government guidance and policy into the development needs of the region (Lloyd 1985). Structure plans consist of a written statement accompanied by a policy of broad land-use designation within the area covered by the authority. The plan does not hold detail of land allocation and is subject to approval by the Secretary of State who may approve it in total or part and require modifications, he may also reject it (Cullingworth, 1982). Structure plans in their early days reflected a growing interest in the need for strategic planning to encompass economic, social and land-use policy (Healey, 1983). However, during the 1980s there has been an enforced shift, originating from central government, from this wide remit to a more restricted one of the general allocation of land-use (Barber 1983). However, over recent years there has been a increase in the profile of these documents and more emphasis is placed on unifying development to meet an identified need for an environmental strategy (Glasson, 1992). This has however, also been accompanied by a growth in the Planning Policy Guidance[3] given out by the DoE around which acceptance of the plan is formed. This guidance includes instructions for the provision of road transport (PPG 13, DoE 1994b) as well as housing targets. Referral of a plan by the DoE for not considering these guidelines has occurred and has led to a present day situation where much of the county's planning function is unsure and heavily influenced by central government (Planning Week, 11th August 1994).

Local TPPs are essentially an annually updated supplement to the county's structure plan and includes the county's transport policies and the public transport provision plan. The aim of this document is to identify and justify the resource needs for road transport infrastructure and the provision of public transport. The plan aims to fit these around the needs of the local population. Although there is little in the way of guidance or set method for doing this (Lloyd, 1985).

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[2] see glossary

[3] see glossary

4.3.3.2 District Authorities

The second tier of local authority was established in the late 19th century and was defined by the need for local management of public health and sanitation (Ratcliffe, 1989, Seeley, 1978). Borough Councils came into their own in the 1950s as a result of the 1947 Town and Country Planning Act which introduced the first concepts of local plans with the aim of providing satisfactory and sanitary housing provision in the post war period (Ratcliffe, 1992). The result of this foundation is a strong emphasis placed on the borough authority to carry out the remit of local environmental health, a remit which was strongly enforced in the 1956 Clean Air Act in the area of air quality management (see Chapter 4.3.1).

This origin is shown strongly in the present day remit of district authorities, which includes housing, refuse collection and disposal, street cleansing, local planning, education and transport engineering functions (the latter three are delegated from the county authorities). To these ends the district authority contains three key departments:

- **land-use planning** responsible for local plan provision, these authorities are now an essentially enabling body, providing development land for residential, industrial and commercial use.
- **transport planning** who hold delegated powers from the county authority to manage and plan transport provision within the districts boundaries; and
- **environmental health** is a department which holds responsibility for maintaining the urban environment in such a way as that *"living conditions are conducive to good health"* (Lloyd 1985). The remit of this department includes local public health and safety at work, food hygiene, litter and noise impacts on the population, and local pest control, sanitation and smoke control powers under the Clean Air Acts (1963 & 1968) The scope of this department is expected to be increased under the 1995 Environment Act.

The main duties of the authority are concentrated within a strong a departmental structure, centred around their own working remits, which traditionally have been very segregated (Knowles, 1983). However, recently there has been a growing consensus towards the co-ordination of departments within and between authorities which has been achieved to varying degrees in different authorities (Ratcliffe, 1989), a feature illustrated by the following quotes from local authority officers:[4]

> *"we now tend to have all the main departmental groups consolidated into one group and this can work well. Co-operate working can lead to communication - but it is personality dependent." (A Bedford Borough Engineer, Interview 07/07/96)*

> *"In my experience from the past we have been out on a limb, but we're working now towards a more structured approach" (Bedford Borough's Chief Environmental Health Officer, Interview 11/07/96)*

The role of the borough authority as the principle controller of local development over the last two decades has, however, been weakened by a series of direct governmental interventions such as the establishment of Local Development Agencies, the strengthening of the appeal system and the introduction of planning constraints. However, perhaps the

[4] source of interview data is detailed in the following chapter

main weakening of this tier of government has come about due to the excessive constraints on financial resources imposed by central government. These are generally perceived as inefficient for most local authorities legislative needs.

4.3.3.3 Unitary Authorities

At present there is a new move towards the merging of county and local authority functions in specific areas under the umbrella of unitary authorities. These new unitary authorities are meant to facilitate a better co-ordination of economic, land-use and transport development. However, much issue has been raised over the staffing of these new authorities and the number of independent development agencies that these larger authorities tend to contain.

4.3.4 Relationships Between Central and Local government

It is useful to note at this point that the relationship between the local governments and central government has changed quite radically over the last three decades, from one of the regulatory control of supply and demand, based in the public welfare paradigm of Keynesian economics, to one of regulation by the "the invisible hand" of Libertarian economics. However, the structure and working practices have changed little and are still essentially those of the plan based system of the 1960s and 70s. This has resulted in a general distancing of local and central governmental mind-sets. This has resulted in practical limitations on local government legislatary powers to affect development within their jurisdiction as well as what may be more important, a demoralising effect on local authority managers (Saunders and Williams, 1986; Brindley, Rydin et al. 1989; Healey, 1990a). This point is illustrated the following comment from a local authority planning officer when asked by the interviewer about the councils role in controlling urban development (Bedford Boroughs Planning Research Officer 1996):

> *"Local government now only produces plans, we are enablers, we don't do anything about it."*

4.3.5 Relationship Between the Public and Government, interest or participation?

The background to approaches of involving the public in decision making and local management in the UK has been described as being so unclear that it is difficult to detect if any particular duty has been laid on local authorities as a whole (McAuslan, 1980). This had tended to lead to a wide variety of participation exercises at local level from carrying out the statutory minimum to wide scale community involvement through local interest groups. However, the norm is that public involvement tends to be in the form of social impact assessment centred around guidance[5] issued from central government level, or through the active involvement of interest groups (McAuslan, 1980).

Central government guidelines tend to take the form of advising the application of comparative methods developed from research from places where public involvement programmes are in existence (e.g. TRRL, 1980; Wigan and Broughton, 1980; OECD, 1990), or from generic modelling studies into social impact assessment based economic or social analysis of the standardised human (Hagerstrand, 1970; Williams, 1994) or the generic application of results derived from such studies (Burdge, Williams et al., 1994). Examples of such exercises are detailed in the following chapter.

[5] see glossary

Public involvement, beyond what can be described as the purely comparative level, usually derives from the activities of often issue-oriented interest groups or specifically designed public platforms (Healey, 1990b). A good example of the latter case are the array of Local Agenda 21 groups. It is rare that local decision makers approach *their* local population directly.

At the central level participation is essentially carried out through the public enquiry process and the right to appeal (Cullingworth, 1982), a system first established by the 1969 Town and Country Planning Act (Department of the Environment, 1968). Any objections by the public are to be considered by the Secretary of State in the context of other factors of public interest, such as economic development. However, while this latter mechanism was at first hailed as an innovation in participation, the reality over the last twenty years is that public objection and debate has come secondary to other considerations, particularly the implementation of central government philosophy concerning the use of free market mechanisms typified by the dominance of cost benefit analysis[6] (McAuslan, 1980).

Both approaches within the UK decision-making process have been identified as essentially belonging to the ideology of public welfare (Benwell, 1980; Healey, 1990b). Policies and goals are formulated by professionals and handed down from high (McAuslan, 1980), and the public are seen as passive recipients of action or public education (see for example DoE, 1994a; DoE, 1994b; DoE, 1995; DoE, 1996). This situation is illustrated with particular reference to air quality management in the next chapter 7.

4.4 Summary

When one looks at the framework for managing problems of environmental degradation, and specifically air quality, one observes a multi-tiered and highly fragmented structure which has evolved over many years to deal with a wide range of historical problems. Some of these problems are relevant today but many are not. The evolution of this structure has centred on the need to manage specific issues and has lead to a professional segregation at both national and local government level, with each department having their own remit and culture in dealing with their traditional areas. The scale on which these different tiers of administration act are essentially influenced by historical settlement patterns overlain with recent modifications driven by the need for economic development.

When one looks at the relationship between the different segments of the framework, one can detect two distinct cultural approaches to decision making (Table 4-2). The first of these has been termed a strong pluriculture (Fox, 1973; Bate, 1994) between the EU and member states and is represented by the concept of subsidiarity. While the actions of the member states are constrained by set minimum standards for action, issued from the European tier, the national government has a strong representation in setting these standards. Goals and aims are designed through a strong negotiation process between these two interest groups represented by the Council Commission, as is the way these instruments are to be implemented and given budgetary allowances (Linter and Mazey, 1991).

The second approach to management can be found between the national and local level, as well as between government and the general public. This relationship shows the general characteristics of what has been termed a uniculture (Fox, 1973; Bate, 1994).

6 see glossary

Táble 4-2: Generalised Characteristics of Unicultural and Pluricultural Approaches to Organisational management (after Bate, 1994; Fox 1974),

Pluriculture	Type of Culture	Uniculture
Top-down/bottom up, emergent.	**Approach**	Preplanned; top-down; set goals or end-states.
Accommodation and interdependence, collaboration and co-existence between competing interests.	**Aims**	Assimilation and integration of different groups to a set aim. Elimination of conflicting interests and perspectives, coercion and creation of shared values.
Dynamic equilibrium achieved by maintaining a viable collaborative structure, within which different groups can pursue self interest and participate in defining the terms of their interdependence, based on mutual co-operation in the definition of aims, and mutual adjustment in setting aims.	**Processes**	Unification of value sets, interests, goals and aims of lower tiers and employees. Definition of Common Goals and Aims from above.
Conflict resolution, coalition type bargaining backed by the threat or use of sanctions.	**Methods**	Legislative, resource, ideological and behavioural control.

The relationship between central and local government is typified by top-down control from central government level through legislation and strongly enforced policy guidance (by the use of appeal and call-in system) and tough budgetary control. The goals and aspirations of activities are formed by central government with little credence given to consultation with local authorities (a point illustrated in chapter 8).

The relationship between the public and the decision makers is likewise highly controlled. The approach to public involvement is based firmly within the public interest ideology (McAuslan, 1980) where the population are seen as passive recipients of policy or negotiated with through strong interest groups (Healey, 1990b). Goals are promoted to the public through educational programmes or by imposing financial or legislative constraints on behaviour (a point followed up in the next chapter). Beyond the influence of general public opinion expressed through elections there is very little input of public ideology and desires into the policy process (Hagerstrand, 1970; McAuslan, 1980).

The next chapter will explore this framework with particular reference to air quality management policy. It reviews the present UK National Air Quality Strategy and will illustrate how this strategy and associated policy is being put into action through local and national activities.

5. The Tiered Policy Framework for Air Quality Management in the UK.

Using a range of primary and secondary data, this chapter builds on the previous one by detailing the evolving policy for the management of ambient air quality in the United Kingdom. It considers policy from European to local government levels and reviews how this policy is taking form on the ground. The policy is critiqued in chapter 8 of the thesis against the light of the studies' investigation into physical and social issues surrounding tropospheric ozone.

> *"The important thing for Government is not to do things which individuals are doing already, and to do them a little better or a little worse; but to do those things which at present are not done at all."*
>
> (John Maynard Keynes, 1926)

The policy context for the abatement of specified air pollutants exists within a geographical and institutional framework ranging from international agreements to local policy guidance and directives (discussed in the previous chapter). In the UK the strategic framework within which air pollutants are formulated can be found in the DoE documents "Air quality: Meeting the Challenge" (DoE 1995b) and "Improving Air Quality: A Discussion Paper on Air Quality Standards" (DoE 1994). These have recently culminated in the publication of a major piece of legislation and central government guidance. These are the 1995 Environment Act, Part IV (DoE 1995a) and the UK National Air Quality Strategy (DoE, 1997).

This chapter will review some of the most influential legislative developments in the management of air quality from the European to the UK local authority levels and the constraints and enablements that these place on the management of ground level ozone.

5.1 Data Used

Central government policy is covered by an in-depth review of the UK Air Quality Strategy and the 1995 Environment Act (Part IV), while local government action and evolving policy is investigated using documentary sources, Internet sources and data gathered from a series of interviews with local authority officers in the Bedfordshire region. Some secondary data gathered from a study into regional monitoring plans are also used (see Hadfield, 1994).

At present policy development for the local management of air quality in the UK is rapid. Indeed, during the period that this study was undertaken a series of major developments have occurred at the European and UK national and local government levels. To reflect this rapid change and the fact that guidance is at present in a continuous stage of development, this chapter draws heavily from information provided by the professional journal *Air Health Strategy*, produced by *Information for Industry*. The journal's remit is to inform professionals in local authorities or industrial sectors over the most recent developments in air quality legislation and guidance.

5.1.1 Interview Method

Interview data was collected from a case-study into air quality management in Bedford Borough Council carried out in the summer of 1996. This took the form of semi-structured discussions of what councils officers felt were the implications of the 1995

Environment Act (part IV) and the (as it was then) forthcoming UK National Air Quality Strategy. The duration of each interview was approximately one hour and full transcripts are presented in appendix 2.

Interviews were carried out with the following professionals:

• The Senior Transport Planner	Bedford County Council
• Head Of Planning Research Green Space Officer	Bedford County Council Bedford County Council
• The Chief Environmental Health officer The Senior Pollution Control Officer	Bedford Borough Council Bedford Borough Council
• The Borough Engineer The Planning Policy manager	Bedford Borough Council Bedford Borough Council

The main aim of the interviews was to get a clear understanding of the roles that officers are expected to play in formulating local (or any regional) strategy as well as any of their perceived difficulties in achieving the aim of air quality on both an explicit and implicit level. To this end it was requested that interviewees would be met separately, however only one agreed to this and in the end the most interviews where held in small groups, as indicated above. The data collected from these interviews will be used to annotate points raised in this chapter, as well as in chapters 5 and 8.

5.2 The European Union

Legislation from the European Union can be divided into two groups: emission control standards and a developing framework for ambient air quality standards.

5.2.1 Directives on Emission Standards

The evolution of directives on emission standards have been centred around the aim of implementing the concept of BATNEEC into the manufacture of motor vehicle fuels (NSCA, 1996), engine design and emission control techniques. It has been essentially driven by the availability of the technology itself (Hadfield, 1997). A major influence on the actual standards put forwards by emission control legislation has been recognised as being the need to not put any individual nation's car manufacturing sector at a disadvantage. This consideration has been influential in discussions about what limits should be set as well as the time-scale for their implementation (Himanen, 1992; Alberti, 1994; Jones, 1991; Directorate Generale XI, 1992).

The present state of the EU emission standards for pollutants from motor vehicles essentially promotes the manufacture of petrol driven cars to include the fitting of the three way catalytic converter (NSCA, 1996, DoE 1997). It is these emission standards that are identified as the main tool that member states need to implement in order to meet the objective of any set air quality standards.

5.2.2 European Air quality Standards

The aims of the directive on European Union air quality standards are laid out in the document COM (95) 109 (CEC, 1995) and are stated as:

> *"To create a harmonised strategy, to identify areas where actions need to be taken to improve air quality, to highlight the need for other legislation, to allow for the measurement of impact of control measures, to create links to modelling and inventories and environmental and health assessments"* (from NSCA, 1994).

To these ends the directive states the following principles:

i) to fix objectives for air quality limit values and thresholds;

ii) the assessment of air quality in a uniform manner across all European Member states, under the constraints of article 100(s)

iii) to make available air quality data to the general public; and

iv) to maintain and improve ambient air quality.

The directive specifically identifies six pollutants and while it does not set numerical standards (it is intended to be a framework for managing air quality within standards) it does state that standards will be set on the basis of best scientific evidence of health effects of each individual pollutant acting in unison. Air quality standards already in existence (see Table 5-1) will be modified to include guide and limit values for all pollutants and these include NO_x and O_3. However, while some organics, such as benzene, are specifically mentioned on the basis of direct individual toxicity, the VOCs as a group are not included.

The standards are adapted from existing directives on air quality and are based on the

Table 5-1: Examples of Existing Air Quality Directives that are under COM 109 (95)

pollutant		standard (in µgm)			EU Directive
		reference period	limit values	guide	
ozone	vegetation protection	1 hour mean	200		EC directive 92/72/EEC
		24 hour mean	65		
	Health	8 hr mean	110		
	population information	1 hour mean	180		
		24 hour mean			
	population warning	1 hour mean	360		
NO_2		one year (98 %ile of 1 hour means)	200		EC directive 85/203/EEC
		one year (50 %ile of 1 hour means)		50.	
		one year (98 %ile of 1 hour means)		135	
SO_2		24 hour mean		100-150	EC Directive 80/779/EEC
		one year mean		40-60	

(after NSCA, 1996)

individual pollutants.

The directive itself does not set any quality guidelines, which are intended to be set by a series of daughter directives, but sets the scene for the role of guidelines in what is termed a *"holistic health based approach"* (NSCA, 1996). This approach lays the foundations of an EU air quality strategy. The daughter directives will identify two values for air quality standards being:

> **current permitted values** these are levels that are set over the short term and are intended to be made stricter as time progresses, reflecting the possibility of improving air quality. Local pollution levels should not exceed these standards.
>
> **long term limit values** these are more stringent still and represent goals toward which air quality management should aim within a predefined time period.

The directive defines three criteria for grading regions (a region is to be defined by national government) by their air quality with respect to a series of limit values, current permitted levels, and long term limit values, and each of these regional designations carries with it management requirements. These are:

i. **Areas of Poor Air Quality** where air quality exceeds current permitted values. In these areas measures and programmes must aim to meet current permitted values as quickly as possible and achieve the long term limit value in the specified time.

ii. **Areas Of Improving Air Quality** are defined as those where air quality is between a current permitted level and a long term limit value. No increase in the pollutant(s) is allowed and the area must achieve long term limit value in the time period specified.

iii. **Areas of Good Air Quality** occur where air quality is under the long term limit value and no action is required.

Monitoring criteria, modelling, and estimation techniques will be fixed by the EC and be mandatory for agglomerations of more than 250,000 inhabitants (at a population density of >1000 inhabitants/km^2) and other areas identified as being of poor air quality. In addition to these criteria the directive also lays out a list of requirements of the member states as follows:

i) to implement the directive

ii) to accredit laboratories for air quality assessment

iii) where exceedances occur there is a requirement to inform the Commission of the following:

- locations of exceedances,
- background meteorology and topographical data,
- authorities responsible for improvement plans,
- nature of pollutants and their assessment techniques,
- pollution sources and quantities,
- existing control measures,
- new measures aimed at reaching the directive's requirements, and

- any long term projects in place.

The responsibility for drawing up improvement measures and plans rests with the member states. This is also the case for the designation of responsibility for achieving the targets and associated management (Commission for the European Communities 1995).

The emphasis of this legislation essentially lies in the setting of harmonised standards for named single pollutants, for monitoring compliance, information concerning monitoring methods, and supplying information from the member states to the Union concerning the design and designation of management frameworks. The directive will be implemented through a series of daughter directives setting European standards for sulphur dioxide, nitrogen dioxide, carbon monoxide, benzene and ozone by the end of 1998 (Air Health Strategy November, 1996). Management directives are defined as short term plans for dealing with incidents where limits set by these daughter directives are exceeded. While they include a requirement to inform the public, it is stated that this should be done in the most simple way as possible to avoid complex or costly systems (Air Health Strategy February, 1996).

5.3 Summary of the United Kingdom National Air Quality Strategy.

The recently released UK air quality consultation draft (DoE, 1996) aims to set the targets, framework and mechanisms of achievement for air quality over the next ten years. The document sets the scene for UK policy (i.e. the principles and background) and explains the international context. It also outlines the scope and objectives of the policy and details mechanisms by which these objectives are to be met. A stated aim of the legislation is to set out regulations and guidelines for the designation of air quality management areas. The following section reviews the chapters of the UK strategy that are relevant to this thesis.

Chapter 1 sets the scene of the act and states the principles on which it has been devised (Table 5.2). It emphasises the need to break down the barriers between environmental and development planning, and establishes the position that air pollution is essentially regarded as a human health problem. The chapter states the aim *"to minimise hazards and maintain the environment to a degree that human health and safety are not impaired"*.

It then advances the view that the issue of air pollution and health is most relevant for the sensitive groups in our society, but concludes that *"...better air means a more pleasant living environment for all"*. The consideration of air quality as an issue of improved well-being, rather than one which relates purely to toxicology and health, is restricted to this one sentence within the whole document.

The latter part of this chapter explains the rationale surrounding the timing of the strategy. It notes the importance of peer-reviewed scientific evidence as the driver for any regulations resulting from the strategy, and points out that the scientific understanding of air pollution issues has increased markedly in the last decade but that the knowledge base is still incomplete. The chapter continues that government policies have marked a comprehensive approach to controlling vehicle emissions. No mention is made, however, of the effect which other road transport related policies such as the deregulation of public road transport and the privatisation of the rail companies, may have on overall emission rates.

Table 5-2: Stated Principles on which the UK Air Quality Strategy is Based

Sustainability	It is a fundamental precept that policy should seek to drive technologies, behaviour and use of resources towards modes of operation which are sustainable in the long run
Effects-Based Approach	The touchstone of action should be environmental objectives, expressed in terms of environmental quality. This allows areas to be treated proportionally to their particular risk of damage using the package of measures most suitable for them to achieve the agreed objectives. Effects include those on human health as well as those on the natural and built environment
Risk Assessment	Quality objectives must be set on an understanding of the relationship between exposure to levels of pollution and their effects. This enables judgement to be made on critical loads and critical levels (defined below) and can inform decisions where there are no critical thresholds (i.e. where effects occur at all loads or levels) or where the costs of meeting critical levels are higher than the benefits.
Sound Science	Risk assessment must be based on internationally robust scientific evidence, published and peer reviewed
Proportionality	Where the case for action is adequately made, the measures should be proportionate to their objectives, in the light of an assessment of the costs and benefits involved. Measures should provide for flexibility in implementing and enforcing international obligations
Polluter Pays Principle	The costs of measures should be decided by authorities to ensure that the environment is in an acceptable state and should be reflected in the cost of goods and services which cause pollution in production and/or consumption
Precautionary Principle	Where there are significant risks of damage to the environment, the government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants even when scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it.
Subsidiarity	Action should only be taken at the European level where a community objective cannot be sufficiently achieved by member states, taking account in particular of transitional aspects
Effective International Monitoring and Enforcement	Ratification of the UNECE Protocols should be followed by national action plans, where appropriate, and reports to the relevant supervisory body. The implementation of the EC legislation should be rigorously monitored and enforced across the community. (after DoE 1996)

The chapter continues by recognising the complex spatial nature of air pollutants and the problem of managing photochemical oxidants locally. It is interesting to note however that spatial factors are referred to on a local and European level and national scale factors are omitted.

The chapter concludes by stating that the framework is restricted to the single issue of air quality and does not concern soil, water and environmental degradation, and that the framework is intended to set the objectives, targets and specific aims for air quality management for implementation at the local level.

Chapter 2 of the report communicates the international context within which the UK Air Quality Strategy sits. It notes the long transportation rates of some of the pollutants such as NO_x and SO_2 and recognises that the UK is a net exporter of air pollution, especially in the winter months. The chapter asserts the view that over half of the photochemical oxidants in the UK are derived from European sources and proposes that this class of pollutants must be managed in the context of European agreements. The chapter reaffirms the need for subsidiarity but refers to the concept only in terms of the relationship between European and National governments. Within this context there is a need for *"confidence that the parties involved must have the willingness and ability to meet set targets"*. It concludes by stressing the importance of national government participation in the setting of European objectives and standards.

Chapter 3 states the aims and approaches behind the setting of standards and objectives for the strategy. This is based on the 'rendering harmless' approach first developed in the 1800s under the Best Practicable Means. This technology based approach currently takes the form of BATNEEC (Best Available Technology Not Entailing Excessive Cost) and stresses the importance of developments improving the environmental impact of current technologies. The chapter states that the framework is designed to be a *"simple and clear conceptual framework ...readily accessible to all parties on whom it bears"* (p 14) and aims to link the myriad of national and European legislation concerning air quality by setting a series of standards, and specific and general objectives. These are defined as follows:

- **Standards**: These are the benchmark for objectives and are *"set purely with regard to scientific and medical evidence on the effects that particular pollutants have on health"*(p 15). They highlight the concentration of pollutants that are broadly considered to constitute a *"certain"* environmental quality. The basis of the standards is the work carried out by the EPAQS (DoE Expert Panel on Air Quality Standards).

  It is stated that standards are set for pollutants on an individual basis because the most recent evidence suggests that there are no synergistic effects on health resulting from mixtures of pollutants, but rather that these effects are additive.

- **General Objectives:** While the health effects of individual pollutants are stated as the main driver for setting standards, the objectives through which these standards are to be met have been formulated taking *"due consideration of cost and benefits, and the feasibility and practicality of moving towards those standards"*. The primary objective of the strategy is that *"air quality policy should be directed towards getting air quality as close to the bench mark standards as proposed as is reasonable and justified on consideration of the costs and benefits"*. The time scale for achieving the objectives is set at 2005 to allow for *"substantial improvements in vehicle emissions" (p17)*, although it is proposed that policy should aim at meeting standards before this date. The general objectives defined by the government are:

- the direct elimination of levels exceeding air quality standards for CO and Pb.
- to eliminate levels exceeding standards of NOx and fine particulates during winter smog episodes (although the connection with photochemical smogs is noted). The detail of the objectives is laid out in the following section on specific objectives.

- **Specific Objectives** to be achieved are shown in Table 5-3. The document notes that there are *"considerable uncertainties"* as to whether these objectives will be attainable for the whole country. These uncertainties include climatic conditions and the accuracy of the predictions about the reductions that are expected from planning measures. It is noted that these measures only apply to areas where people are *exposed* over the relevant averaging period.

Table 5-3: The proposed specific objectives of the UK Air Quality Strategy (after DoE 1997)

Pollutant	**Standard**		**Specific objective**
	concentration	**measured in**	
Benzene	5 ppb	running annual mean	5 ppb to be achieved by 2005
1,3 butadiene	1 ppb	running annual mean	1 ppb to be achieved by 2005
CO	10 ppm	running 8hr mean	10 ppb to be achieved by 2005
Lead	0.5 $\mu g/m^3$	annual mean	0.5 $\mu g/m^3$ to be achieved by 2005
Ozone	50 ppb	running 8hr mean	50 ppb measured as the 97th percentile to be achieved by 2005 (provisional)
PM_{10}	50$\mu g/m^3$	running 24hr mean	50 $\mu g/m^3$ measured as the 98th percentile to be achieved by 2005
NO_2	150ppb 21ppb	1hr means annual mean	150ppb annual mean by 2005
SO_2	100 ppb	15 minute mean	100 ppb measured as the 99.9th percentile to be achieved by 2005

The percentile approach[7] is claimed to be used for non-compliance due to adverse weather or cultural events. It is intended that these objectives will be met

[7] see glossary

by national government action and through the Environment Act 1995 (see page 88).

Any new European limits to be implemented from the draft directive on air quality (CEC 1994 **com** (94) 109 final) will take precedence over these standards; however these are not expected to be implemented until early in the next decade. There are no standards for protection of human health, or as yet for VOCs.

Chapter 4 sets out the main policies aimed at achieving these standards and objectives and stresses the approach of controlling pollutants on an individual basis. The chapter assesses whether policy approaches are likely to succeed, and in case of doubt tries to identify if there are policy gaps. It is expected that existing policy will achieve the standards for Benzene, 1,3-Butadiene, Carbon monoxide and Lead by 2005, however, in order to meet the standards for Sulphur dioxide, particulates, nitrogen dioxide, and ozone further measures will be required. These further measures are stated as the key aims of the strategy. Measures are to be within the context of BATNEEC within the IPC[8] framework, and "*careful assessment of costs and benefits*" in that any measures adopted which incur costs should *"achieve equivalent or greater benefits and (...) the option taken could not be substituted by another that achieves the same benefit at less cost"* (para. 12). Where action is taken at the local level it is stated that this may be regarded on a project-by-project basis in terms of local costs and benefits. A central part of this chapter is taken up by a discussion of the calculation of costs and benefits of air quality management techniques.

The main thrust of the chapter is that while local authorities are encouraged to draw up integrated plans for managing air quality through the 1995 Environment Act, national policies are essentially orientated around improving the technology of emission control, increasing fuel standards and the application of BATNEEC to industry.

Chapter 6 reviews the government's approach and suggests methods for incorporating air quality considerations into transportation management. The chapter begins by recognising the complex nature of traffic pollution and the dominance of this sector in air pollution. This dominance is particularly relevant in the Bedfordshire and Hertfordshire region.

The government recognises that the more stringent emission standards that have been in place over the last five years or so have been outweighed by the general growth in traffic (p44. para. 1). However, the chapter then states that emission controls are the backbone of transport policy in relation to air pollution and that on the basis of emission standards alone it can be expected that air quality targets will be met until the year 2010, when it is thought that predicted growth in traffic will cause air quality to deteriorate once more.

The mainstay of the chapter is a statement of the context within which road transport management for improved air quality sits. The statements of principle are that:

- transport is a central part of a thriving economy;

[8] see glossary

- the country needs a "*modern*" (an undefined term) transport system with as little adverse impact on the environment as possible; and
- that this *must* be achieved in a way that secures "*personal safety and freedom of choice*".

The approach taken to reduce these environmental impacts is essentially one of introducing emission controls and set methods to control the quantity and growth of road transport in particularly sensitive areas.

To achieve this end the approach taken by the government will be four fold:

1. Improvements in vehicle technology is stated as central to the transport part of the UK Air Quality Strategy and is seen as the main contribution to improving air quality, in line with the principle of cost effectiveness.
2. Implementing tighter controls regarding vehicle fleets and their management, including tighter emission standards and the stricter enforcement of standards for motorists. This will extend the role of emission testing within the MOT and allow for local authorities to emission test private vehicles. However, local authority employees will not have the power to stop motorists for emission testing, this remains confined to a uniformed police constable (see the 1995 Environment Act Part IV section 87.6).
3. Development of "environment responsibilities" by fleet operators (specifically public service operators), and by the public at large. Measures to promote this include: the introduction of an annual increase in road tax (5%) to place more of the real environmental cost of motoring onto the consumer; to promote greener motoring; to encourage or impose the take up of environmental responsibilities on public transport companies; to establish new powers for local authorities to restrict or discourage private transport use in local areas by the permanent or temporary imposition of restrictions on parking space and the closure of roads to motorised traffic.
4. Changes in planning and transport policies to reduce the need to travel and reliance on the motor-car. These are seen as long-term solutions of infrastructure development to promote less car dependent urban environments.

The basis for this approach is laid out in the government green paper "*Transport the Way Forward*" (DoE 1996) which is guided by the most cost effective approach. It is recognised that traffic management, technology and planning policy operate on different time scales.

It is also noted that central government will not place emission standards on a sectorial basis such as road transport. The view taken in the document is that air quality related management of the transport sector requires national and local level management. The national role is seen as one of introducing (financial) disincentives on vehicle use and that the definition of emission standards is a process of negotiation between central and European government. The other major policy initiatives which are specifically mentioned are the privatisation of the rail network and the building of bypasses. It is the opinion of central government that rail privatisation will breathe new life into rail travel, and that bypass building relieves congestion and removes the body of traffic away from areas of urban population. Further tasks for central government are introduced as the "*education of the public*", and the need to "*encourage debate in this area*".

The funding of local authority measures is to be decided by the DoE on the merits of bids placed by local authorities based on packages of proposed measures.

Chapter 7 Describes the role of local authorities in air quality management and to a great extent reiterates what is outlined in the 1995 Environment Act (see section 7.3). The chapter notes the approach to the phasing in of regulations and requirements, and the single medium approach. However, in this context the government recognises that "*in some circumstances, it will be a positive advantage to look at the local environment as a whole*" To this end the government states a wish to "*encourage co-ordinated and focused local approaches to urban environmental management and will consult with local authorities on how to do this*".

The latter part of this chapter is concerned with those voluntary measures which are to be encouraged. This section of the report points out that a major source of industrial pollution is derived not from direct emission but from the transport associated with industry such as vehicle fleets. To this end the strategy suggests the development of green commuter plans, including:

- incentives to buy season tickets, such as the easy payment schemes, for public transport or park and ride;
- effective management of car parking, with allocation of spaces based broadly on operational needs. The real cost of parking includes land and maintenance, and some of this may be passed onto users;
- information and incentives to encourage car sharing;
- information about public transport; and
- incentives for using bicycles, such as bicycle loans, cycle user groups, facilities for storing and locking equipment, and showering facilities in the work place

The chapter argues for individual commitment to air quality being promoted, for example, people may want to consider where the nearest bus route or train route is when purchasing a house (chapter 7 para 54). Alternatively support might be provided for the publication of booklets to promote more "*environmentally benign driving behaviour.*"

The summary of this part of the strategy concerns public information provision on a wide range of air quality issues and a statement on how teaching materials on air quality can be developed for the national curriculum.

The overall approach of the strategy is to integrate the issues and decisions of all those whose actions can influence air quality, within the standards framework. The holistic health based approach is essentially the same as that taken in the EU directive on air quality (CEC 1994), it will be proposed that it represents more of an amalgam of approaches traditional to air quality management rather than a fundamental restructuring of air quality management (refer to chapter 8).

The UK air quality strategy aims to agglomerate existing pieces of legislation and introduce new guidance with the aim of forming the structure of air quality policy in the UK until 2005. While the strategy forms more of a statement of intent, the legislative content of present UK air quality policy lies in the recently published and as yet to be enforced 1995 Environment Act (part IV).

5.4 Part IV of the 1995 Environment Act

The 1995 Environment Act was published at the end of November 1995. Part IV of the Act lays out a set of duties required for different authorities to manage air quality. These are summarised as follows (italics added by author):

- The Secretary of State shall as soon as possible, prepare and publish a statement containing policies with respect to the assessment or management of the quality of air (see section 7.2) -80(1).
- In discharging its pollution control functions, each new (environment) agency shall have *regard* to the strategy -81(1).
- Every local authority shall from time to time cause a review of local air quality for the both present and likely future quality within the *relevant* period, - 82(1).
- When carrying out the review a local authority must assess whether air quality standards or objectives are being achieved-82(2); if not, the local authority must identify *parts* of its area where these standards are not being, or likely to be, achieved 82(3). These must then be designated an "Air Quality Management Area" 83(1).
- If a local authority is required to declare an air quality management area, then it must prepare within twelve months of the order being made an assessment of the area and way in which standards are not being met 83(1b) and devise a written air quality action plan by which the authority may exercise *"any powers"* in pursuit of the objective of meeting those standards 83(2b). This action plan must include a statement of time or times by which the local authority proposes to implement each of the proposed measures 83(3).
- In a two tier area the county council may make recommendations to the district as to carrying-out their duties under the above section 86. If there is contention between the county council and district then either may refer the matter to the Secretary of State 83(5a) who essentially plays the role of adjudicator 83(5)
- If the local authorities do not agree on whether an action plan is needed or on the contents of that action plan, designation and assessment falls to the Secretary of State.
- The Secretary of State has the powers to enforce the requirements of the act 83 (1,b & c), revoke or modify any order 83(d), prepare action plans for an area and to implement any part of the action plan 83 (e, f & g).

- The Secretary of State may also give directions to local authorities in regard of obligations under EU treaties and other international agreements relating to air quality 83(5) & 86(7).
- The duties of the county and district councils in a two tier system are that the county *may* make recommendations to the district in respect of any assessment, review or monitoring 86(1) and that the district *shall* take these recommendations into account. In the event of a district drawing up an action plan the county shall submit a proposal to the district.
- The Act also makes it a duty for county councils to take note of the borough's strategies 86(8)
- Section 87 of the act confers wide-ranging powers to the Secretary of State (Association of District Authorities, 1995) including the right to produce regulations prescribing the aims and objectives of the Act, or in connection with its implementation. These may include prescribing air quality standards, conferring powers or imposing duties on local authorities, restricting processes or vehicles in an area, prescribing measures adopted by local authorities and obtaining information on behalf of interested parties or the general public as well as overseeing appeals against measures taken by local authorities 87(4).
- The act also states, 87(6), that no person other than a constable shall stop a vehicle on the road.
- In addition to the powers conferred on the Secretary of State, section 88 allows the Secretary of State to issue guidance to the local authorities with respect to the act and requires that local authority action takes this guidance into account 88(2).

The overall aim of the Act has been described as establishing a framework for standards for those pollutants that are of most concern. These tend to be those identified in the EU Directive on Ambient Air Quality Assessment and Management (Commission for the European Communities, 1994). The general approach to the Act is typical of those introduced in the last few years from both the UK and European legislators It promotes a standards based approach for individual pollutants based on probable health effects (DoE, 1995), and to a large extent places the burden of ensuring that air quality targets are met on local authorities.

Part IV of the 1995 Environment Act is peculiar in that the objectives, standards and regulations on which the act is based were not yet set at the date of its publication. Delay in central government publication has been a confusing feature of recent air quality management proposals.

A discussion of the Act in light of the research findings presented in this thesis can be found in chapter 8.

5.5 Local Authority Action

The emphasis for achieving air quality standards rests firmly with the local authorities (DoE, 1997 para. 7.19). This section of this chapter will review the present explicit and implicit constraints on local authorities to manage tropospheric ozone within this policy context. Issues and recommendations for changing the management practices are discussed in Chapter 8.

The departmentalised evolution of local authority structure and the real and perceived budgetary constraints faced by UK local authorities have been noted (chapter 4) and it is against this backdrop that local authority action is set.

The UK National Air Quality Strategy and 1995 Environment Act (Part IV) places the requirements to monitor local air quality against set standards (Table 5.4) and to identify areas where these standards are exceeded, on local authorities. Where exceedance does occur it is a local authority duty to designate air quality management areas and draw up strategies for reducing the concentrations of that particular pollutant. It has been noted that funding will only be available from central government to local authorities to allow them to meet their statutory duties and that the designation of an Air Quality Management Area is expected to be the exception rather than the rule (Air Health Strategy July, 1996a).

Guidelines on how local authority departments are to carry out this assessment of air quality and any associated management requirements are presently being developed by the DoE through the designation of 12 pilot studies or *"first phase authorities"*. A summary of each of these authorities and their goals under the 1995 Act is shown in Table 5.4 From this table it can be seen that the main issues which will be approached are methods of monitoring, public information strategies and, reflecting the transport derived nature of many air pollutants, methods for transport management. Indeed, it is said that findings concerning these three issues will form the corner stone for local authorities to fulfil their duties under these acts (Air Health Strategy November, 1996a).

It is therefore useful at this point to look at the approaches that are being developed by the DoE to establish best practice for these functions, although it is expected that the official publication of the government recommendations for action in these areas is not expected until later this year (1998).

5.5.1 Emerging Approaches to Assessing Air Quality.

The 1995 Environment Act has to a great extent fallen onto the remit of the Local Environmental Health Office who have the task of assessing local air quality. Reflecting this, the main offices expected to be affected by the 1995 are Environmental Health Departments. This point is supported by the following quote from Bedford's Borough Engineer (1996):

> *"The* (Environment) *Act to be in place by July 1997 and the job plan falls to the Director of Environmental Health and Housing, (...) at first sight it is essentially collection of monitoring data."*

Table 5.4 ***The first phase local authorities designated by the DoE to pilot approaches for air quality management***

Authority/ Consortium	Character	present work	goals
London - 33 London Boroughs under the London Air Quality Network *(local health authorities)*	urban with some industry	extensive continuous air quality monitoring with NETCEN sites	identify urban corridors, develop a public information strategy
Cambridge- Cambridge County and District Councils *(transport and planning local health authorities)*	Urban, suburban, rural	monitoring and public awareness through local agenda 21	modelling to predict wider levels based on existing monitoring data, emission inventory
Hampshire - Hampshire County Council,, Isle of Wight Unitary Authority, Hampshire District Councils (University of Southampton)	Urban, rural, industrial	continuous monitoring in Winchester and Southampton, mobile monitoring in Portsmouth,	extend emission inventory, extend air quality monitoring network public information strategy
Cornwall, County Council and six district authorities	rural	none	conferring with the DOE
Avon - North Avon, Bath City, Kingswood, Wansdyke, Bristol City and Woodspring Unitary Authorities	urban, rural some industry	none	waiting to talk to DoE
West Midlands - Birmingham, Wolverhampton and Coventry	urban industrial	DoE monitoring sites in Birmingham	increase DoE monitoring status
Derbyshire - Northeast Derbyshire, Bolsover Chesterfield, High Peak and Derbyshire Dales *(health authorities)*	rural with heavy industry	SO_2 and NOx monitoring; local monitoring of dioxins	waiting to talk to DoE *
Ribble Valley	rural with heavy industry	local monitoring around cement industry in Clitheroe; wider dust deposition monitoring	continuous monitoring or mobile SO_2 monitoring equipment up and down wind of cement works
Merseyside - Met authorities of Knowsley, Liverpool City, Sefton, Clitheroe, St Helens, & Wirral	rural, urban, industrial	continuous NETCEN Monitoring, mobile monitoring of smoke and SO_2 NOx and some monitoring of lead in docks	confirm monitoring programme is appropriate for the area and upgrade if not. Otherwise follow DoT suggestions and advice
South Yorkshire - Rotherham, Barnsley, and Doncaster Metropolitan Areas, but concentrating on Dearne Valley Area	industrial, urban with some rural	monitoring NOx, SO_2, CO, ozone, NOx, and hydrocarbons	portable monitoring stations
South Wales - Unitary Authorities of Neath, Port Talbot and Swansea *(local health authorities)*	urban, industrial	continuous and project monitoring in Swansea looking at air quality and asthma	work on traffic emissions and modelling.
Aberdeen City of Aberdeen Unitary Authority	urban with some open spaces	smoke/NO_2 monitoring	real time monitoring,, public information systems
Glasgow- City of Glasgow Unitary Authority	urban with some open spaces	smoke/SO_2, metals, two NETCEN sites, emission inventory being prepared.	Goals identify hotspots otherwise waiting to talk to Scottish office
Tyne and Wier - Metropolitan Authrorities of Gateshead, South Tynside, Sunderland, under the Tyne and Wier Air Quality Management Group	urban industrial	DoE monitoring sites in Newcastle, traffic monitoring	scoping study and hot spot monitoring

However, the local Environmental Health Office does not entirely share this view in the event that the assessment of air quality would require further action, as is shown by the following quote, although they do recognise the remit of monitoring falls with them:

> *I think our role is to primarily collect information, and to monitor the environment. I think decisions will be made upon the data we collect. We will be part of that decision making process. But given that transportation policies and land use policies are going to bring more information to improving the environment, I think that the lead role will be in those areas, not necessarily in ours. Traditionally, our role is to collect data.*

(Chief Environmental Health Officer, Bedford Borough Council, 1996)

At present the approach to monitoring air pollution in the UK is shared between the DoE's air quality monitoring network (NETCEN) and local authority monitoring, usually in response to single issues, carried out by local environmental health departments. Under the Environment Act it will be the duty of local authorities to develop techniques for assessing air quality to ensure that the locality meets air quality standards. The stress placed on the approach is one of *cost-effectiveness to local need* (DoE, 1997). While many of the phase one pilot studies stress a desire for funding of local mobile monitoring equipment, it is generally recognised that this will not be forthcoming (Air Health Strategy March, 1996). The approach of the DoE at present is essentially to expand the Urban Air Quality Network monitoring to cover a wider range of pollutants and to require local authorities to use this data or to use other methods for estimating air quality such as modelling or emission inventories. This approach is considered by many local authorities to be less than satisfactory for their needs. This point is illustrated by the following reply to the question "In order to prepare a complete assessment of air quality in the area, do you need additional monitoring?"

> *"Undoubtedly, we will need to have additional monitoring. The information we've got is based on diffusion tubes and pilot surveys. If we're going down the road to the DoE in terms of advocating using databases as emissions characteristics, we could get a broad brush inventory for our area. At that stage we have to start and model and estimate what the concentrations are, then we will need to look at additional monitoring."*

(Bedford Borough, Senior Pollution Control Office, 1996)

Monitoring that is carried out at the local level or using DoE automatic equipment, takes place at fixed sites in areas that are of most concern (Air Health Strategy May, 1996). Areas which are not expected to reach strategy targets by 2005 will have no requirement to be monitored or assessed again. However, while there is a recognition that Environment Act promotes this approach, many health authorities need to respond to the local concerns surrounding exposure, such as the location of raised pollution hot spots and how the population perceive their local air quality. Since people, unlike fixed sites, do not stand in one place all day, the site monitors are generally not considered adequate to reflect this (Raaschou-Nielson at al. 1996; Air Health Strategy April, 1996). This is a feature recognised by Bedford's Environmental Health Department:

"The act doesn't recognise exposure. All we have to do is to go out and measure and if you exceed that's it. That's the area that has been omitted."

(Bedford's Senior Pollution Officer, 1996).

In answer to this problem many local authorities are looking at measuring or modelling personal exposure to some air pollutants by using focus groups (Air Health Strategy April, 1996), population movement, hot spot modelling (Hansen, 1996), and/or the selective siting of monitoring equipment (Air Health Strategy May, 1996). However, there is little statutory duty surrounding this and recent developments at Central Government have rejected this approach (Air Health Strategy December, 1996).

Perhaps the main issue with the approaches to monitoring and modelling being promoted to local authorities, with respect to tropospheric ozone, is the strong local emphasis. Indeed, the aim of monitoring is only to assess where areas may exceed air quality standards in the year 2005 (Air Health Strategy April, 1996) and if one refers to Table 5.4, it can be seen that the term "area" is generally considered to be local *within* administrative boundaries. A study carried out into the best way to improve air quality with respect to local authority management, and cited by the DoE to be central to its developing guidelines for local authority duties under the 1995 Act and the UK National Air Quality Strategy, states that the best way to improve air quality in small and medium cities (taken from selected European examples) revolves not around a single policy, but a group of policies focused on city pollution hot-spots (Elsom December, 1996). The influence of this report can be seen in the comment of Brian Etheredge of the DoE: "AQMAs need to be defined on local exceedances of roadside air quality (Air Health Strategy July, 1996a). The emphasis on particular localised point source or hot - spot problems at very specific locations is reflected in the budgetary allowances for local authorities being considered by the DoE (see Table 5.5).

However, even within this strong local emphasis on monitoring air and assessing air quality there is a wide range of opinions over the budgetary requirements of local authorities, a point illustrated by comparing the costs actual incurred by the first phase authority, Aberdeen City Council, (Table 5.6; Air Health Strategy November 1996) with the table of costs used for the DoE estimate.

Furthermore, an extension of the local emphasis found in the Environment Act, can be identified if one considers that the remit of monitoring and assessment falls by and large on Environmental Health departments. These departments have a particularly strong tradition of acting on local public concerns, as shown by the following quote:

"the majority of our work is responding to problems from the public, about 75%. We're very responsive to customer's needs."

(Chief Environmental Health Officer, 1996)

The combination of these two features is giving rise to monitoring techniques that are essentially very locally oriented around very specific air quality problems, such as kerbsides and busy junction hot-spots (Air Health Strategy August, 1996).

There is no commitment to look at the regional nature of pollutants or to study the interaction of pollutants with each other. Where regional monitoring regimes are being devised, they are often divided around local authority boundaries rather than on consideration of the location and movement of air flows. The neglect of this feature mixed with the local perspective of standards and requirements under central government guidelines essentially constrains the management of regional and synergistic pollutants like tropospheric ozone in two distinct ways:

Table 5-5 Indicative costs for an air quality review (Air Health Strategy November 1996)

Task	Cost (£)
1. Compile information on air pollution sources	705.00
2. Compile air quality monitoring data	307.50
3. For each pollutant, identify hot-spots	600.00
4. Assess air quality at these locations either by monitoring comparison with similar UK locations, or simple modelling	1462.50
5. Compile information of likely changes in emissions by 2002	442.50
6. Repeat (4) in 2005	862.50
7. Report results to members of the public	937.50
8. Produce documentation	1,200.00
Total	**6,517.50**

Table 5-6 Principal costs incurred by Aberdeen City Council's monitoring station (after Air Health Strategy, December, 1996).

Item	Cost
NOx analyser	10,000
CO analyser	10,000
Continuous particulate monitor	20,000
Auto Calibration System	3,000
Modem	500
Enclosure	7,000
Gas cylinders and regulators	3,000
Data processing equipment	1,000
Site installation	1,000
Staff training	1,000
Total	56,000

1. The monitoring of local high level sites provides poor and inaccurate data for and therefore unreliable calculations in the case of regional photochemical pollutants.

2. By leaving monitoring approaches, monitoring site locations, and definition of local air quality problems, as well as the designation of cross authority collaboration, open to the discretion of local authorities, the act opens the way for poor co-ordination of regional monitoring approaches in an area where pollution levels depend on small

but significant differences in the concentrations of precursor pollutants (see chapter 2.3).

These issue will be pursued in chapter 8.

Emerging approaches to informing the public

The main approach used in grading air quality for public information systems is the generic description of air quality bands (described in Chapter 4) and warnings designed around local air quality standards (DoE, 1997). The definitions of these bands have come under criticism from various groups for the following reasons:

1. Targets poorly reflect exposure in that they are based on fixed point sites;
2. The definition of air quality bands was criticised on the grounds that the original *good* category falls in the area where sensitive groups, and those subject to long term exposure may be recipients of adversary health effects.

This situation has been claimed as misleading (Air Health Strategy July, 1996). In response to this situation new bandings were proposed. These standards essentially scrap the *good* category and introduce the categories *very good* (where the concentration of the pollutant is not considered on scientific grounds to be a threat to anyone's health), *generally satisfactory* or *moderate* where a pollutant's concentration is actually above the safe threshold, *poor* occurs when health effects are likely (Air Health Strategy February, 1997). A new category of *very poor* has since been added. These categories translate into information thresholds (seeTable 5-7).

Table 5-7: Proposed DoE Air Quality Bandings (Air Health Strategy February, 1997)

pollutant	Standard threshold (means)	Information threshold (means)	Alert threshold (means)
SO_2	100 ppb (15 mins)	200 ppb (15 mins)	400 ppb (15 mins)
Ozone	50 ppb (8hr running)	90 ppb (8hr running)	180 ppb (8hr running)
CO	10 ppm (8hr running)	15 ppm (8hr running)	20 ppm (8hr running)
NO_2	150 ppb (hourly)	300 ppb (hourly)	400 ppb (hourly)
PM_{10}	50 μgm^{-3} (24hr running)	75 μgm^{-3} (24hr running)	100 μgm^{-3} (24hr running)

standard threshold lies between very good and generally satisfactory
information threshold lies between generally satisfactory and poor
alert threshold lies between poor and very poor

These new categories have come in for similar criticism as the previous thresholds, Malcom Evens of the National Society of Clean Air (NSCA) states that:

> *"It cannot be right that the use of the terms 'generally acceptable or satisfactory' can apply in areas where local authorities may be required to declare air quality management areas" (Air Health Strategy February, 1997).*

5.5.2.1 Examples of public air quality information systems

Three examples of public air quality information systems have been introduced by Cambridge City Council, Middlesborough Council and the Cheshire working group respectively.

Cambridge's approach to informing the public is through two systems: firstly information is put out through the programme "*Anglia Air Watch*" on local TV networks which uses the DoE system for generic air quality grading; and secondly via an Internet site[9] on which hourly readings of ozone, carbon monoxide, NO_2, and PM_{10} are provided. The aim of this latter project is to allow the public to plan journeys in town more effectively. Roger Coey (Head of Environmental Health, Cambridge City Council) states (Air Health Strategy October, 1996):

> *"by making environmental data available in as open a manner as possible, we hope to help the people of Cambridge make better use of their city, and welcome debate that will lead to more sensible transportation and fossil fuel use."*

The approach taken by Middlesborough Council is through the production and distribution of a leaflet to local residents explaining the importance of air quality and the improvements made over recent decades. The leaflet explains what people can do to improve air quality. In addition to this, Middlesborough Council also issue daily air quality bulletins in the local media, but it is also recognised that 92% of surveyed local residents had never seen or heard them (Air Health Strategy, June, 1996). The leaflet produced by the council is in response to a survey carried out into local perceptions of air quality (Gavin, 1996), which revealed that the general perception of local air quality was poor. It has a main aim of reassuring the local population about the (as it was then) *"good"* standard of local air (see above) quality as well as to promote the area to potential outside investment (Air Health Strategy July, 1996).

Cheshire County council have produced leaflets through their Local Agenda 21 working group to inform the public about the importance of clean air and the threat posed to it by present transport behaviour, and issue daily air quality bulletins through a phone number.

The response by Cheshire was to a survey carried out using focus groups into the local opinion on the quality of the environment which found that while many respondents considered countryside and clean air to be important features of the area (91%), when asked for spontaneous replies to what people considered to be important areas for action in their neighbourhood, only 7% stated air pollution (Air Health Strategy July, 1996b).

Acting on this, the council have produced a Local Agenda 21 page on the Internet [10]which states:

[9] Cambridge City Council *http://www.io-ltd.co.uk/ccc.html. 1997*

[10] Cheshire County Council, http://www.cheshire.gov.uk/cheshpln/la21/ca.htm 1997

> *"The pollutants emitted by vehicles include carbon monoxide, nitrogen oxides, volatile organic compounds and fine particles. The nitrogen oxides and volatile organic compounds react with sunlight to produce ozone, a secondary pollutant that can cause problems some distance away from the source of the emission e.g. rural areas downwind from congested conurbations."*

The page is supplemented by a series of statements advising the local public on better driving behaviour and supported by a local air quality hot-line.

While the "*phase one*" authorities have started issuing local bulletins, it is likely that public information on a local level will only be made regularly available in many areas where particular pollutants meet information and alert thresholds. In other cases it is expected that information will take the form of a one off bulletin at the time of assessment as required under the 1995 Act (Air Health Strategy November, 1996).

5.5.3 Emerging approaches to transport management

At present, the general trend in approaching transport management consists of four main approaches divided on the basis of how quickly they may become effective (DoE, 1997), these are:

1. planning and infrastructure changes - long term
2. changes in transport provision - medium term
3. changes in public attitudes and driving habits - medium/long term
4. emergency measures - short term

The importance of road transport for the local management of air quality can be seen if one considers that of all the government guidelines to be issued under the UK National Air Quality Strategy research projects, the publication on transport management has been described as the most eagerly awaited (Air Health Strategy September, 1996) and in among the stated aims of the first phase authorities has come only second to monitoring as an issue.

5.5.3.1 Approaches to planning and infrastructure

Many of the approaches to planning and infrastructure development intended to reduce travel can be found in the DoE and DTP joint publication *"Reducing Transport Emissions Through Planning"* (DoE & DTP, 1993) aimed at local planning officers and was a central consultation document in the formulation of PPG 12 and 13. Major findings of these documents are shown in table 5.8.

Table 5-8 examples of DTP and DoE guidelines on planning approaches for reducing travel demand and shifting to more energy efficient modes (after DoE & DTP 1993)

Concentrating employment uses in existing centres and other locations well served by public transport.
The development of high density residential areas concentrated near transport nodes and corridors served by public transport.
Releasing adequate housing land on suitable sites within urban areas so as to limit constraints on the housing market and maximise possibilities for households to locate close to employment.
Measure to encourage CO_2 efficient modes especially cycling and walking.
Constraints on development sites with inadequate public transport.
The development of rail/road interchanges to enable people who live away from work to switch from car to rail for long distance travel.
Maintain and revitalise existing central and sub-urban shopping centres.
Ensuring that decisions on the location or relocation of educational facilities include consideration of overall travel demand implication.
Encouraging the location of new leisure facilities where they are accessible by public transport.
Protecting and creating options to service major industrial sites.

Major findings of the report include that planning policies which significantly constrain travel choice with regards to of work could be expected to generate significant economic costs for the area, and that travel demand and provision and land use planning are closely linked and should be considered in the initial planning stage.

The prescriptive nature of this guidance is shown when compared with local authority planning and transport policies (Table 5.9).

However, a driving force behind conservative central government policy was to allow for economic and infrastructure development to continue with as little impediment as possible from environmental considerations (see section 7.2). This appears to be unchanged under the new administration[11]. This leads to recognised inconsistencies as is illustrated by the following quote from a Bedford Borough's Local Borough Engineer (interview 1996).

> *There is a need to integrate Traffic Policy. Highways planning and land-use planning, PPG 13 states that settlement should be situated around transport corridors. However that leads to worsening air quality for residents along those corridors as traffic increases. Also there has been a steady removal of highway planning from the public sector. This is also true of public transport. Central government is inconsistent which leads to a main issue of cynicism of central government at district level.*

This last issue will be discussed in chapter 8.

[11] although this issue is in hot debate at the time of writing

Table 5-9: List of stated policy directives for a selection of local authorities (compare with table 5.8)

Cheshire County Council[12]
Plan for new developments so as to reduce the need to travel by car; shops, workplaces, and housing can be planned near to public transport routes, and Health, education and other facilities close to where people live.
Introduce pedestrian zones and car-free areas - as at Northwich in Cheshire.
Provide park and ride, for example in Chester - to keep cars out of the city and encourage people to use public transport.
Limit car use - through parking controls, providing bus lanes and priority for public transport
Provide and support public transport initiatives and related infrastructure.
Cambridge City Council[13]
Increasing the role played by public transport, particularly buses, including bus-based park and ride and bus priorities.
Supporting increased investment in local rail services.
Limiting car use, particularly in the City centre and at the busiest times, by traffic management, parking controls and investigation of road pricing.
Providing improved facilities for people with disabilities, pedestrians and cyclists.
Considering new road building only where this gives clear and sustainable benefits, particularly in terms of environmental protection and improvement.

5.5.3.2 Changes in Transport Provision

Changes in local authority transport provision can be divided into five approaches:

1. The encouragement or coercement of people away from the use of the private car by economic incentive/disincentive,
2. This essentially remains the remit of central government through increases in road tax and fuel duty to make motorists "*as far as possible cover the economic costs of road use including the environmental costs*". However, local authorities are to be allowed to consider local measures of introducing incentive/disincentive schemes of their own. Examples of these are: congestion charging, local access tolling and area licensing.
3. Provision of better public transport and providing less for private car use; introducing high occupancy vehicle lanes. However, Road closures and restrictions on employer car-parking have been stated as being actively discouraged by the DoE (Air Health Strategy, 1997)
4. Encouraging cycle use and walking as an alternative to using the motor-car. This essentially concerns a series of programmes for changing the public attitude to the use of the motor-car and is covered in section 5.4-3.

[12] Cheshire County Council, http://www.cheshire.gov.uk/cheshpln/la21/tc.htm, 1997.

[13] Cambridge Copunty Council, http://www.cambridge.gov.uk/services/transpol.htm

5. Emergency measures to be allowed are road closures by the local authority in very specific locations where air quality exceeds the "poor" threshold. These are described as temporary measures to be used as a last resort (Air Health Strategy December, 1996b).

5.5.4 Changing Public Attitudes Towards Driving

The approach to changing the attitudes of the public to car driving is formed by public education programmes, as illustrated by the quote from Bedfordshire's Green Space officer

> *"we have to start looking at what our role would be in looking at air quality management in the county possibly through our work on travel awareness and educating the public in better travel behaviour"*

This often takes the form promoting national initiatives, such as the one as noted by Bedford Borough's Chief engineer;

> *"We are promoting a campaign in this county, Travel Wise, to encourage people to think about car problems and alternative means (travel to school, encourage people to other modal split)."*

"TravelWise" is a system of public education being promoted by many local authorities (at present 30 in all, this is expected to grow) and has been described as a transport awareness initiative, pioneered by Hertfordshire County Council, with the aim of changing peoples attitude to the use of their cars (DoE, 1997)[14]. The campaign seeks to make other methods of transport, such as cycling, walking and using public transport a real alternative to the car and can therefore be seen to be an extension of the guidelines laid out in table 7.4-3.

The *TravelWise* campaign aims to raise the issues of transport and air pollution through awareness, as well as changes in transport infrastructure and local integrated strategies. It aims to encourage understanding of the need for appropriate measures to restrain car use as part of a transport strategy. Participating authorities promote a number of events including Walk to School Week, Business TravelWise, publicity campaigns, and events including National Bike-Week, Green Transport Week and other such focus points.

The process itself has been described as an educational initiative aimed at raising awareness of the local population as to the alternatives to car use within council boundaries[15].

The approach of Cheshire County Council is similar in that they have produced a transport plan and publicised it through Local Agenda 21 using Internet pages. The approach of Cheshire's County plan reflects what is laid out in Chapter 7 of the UK National Air Quality Strategy, in that it aims to promote more environmentally benign driving habits by issuing the following guidelines to drivers.[16]

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[14] DoE http://www.open.gov.uk/ dot/tpu/tai.htm#9, 1997

[15] DoE, http://www.open.gov.uk/ dot/tpu/tai.htm, 1997

[16] Cheshire County Council http://www.cheshire. gov.uk /cheshpln/la21/ca.htm, 1997

1. Make sure the vehicle you use is properly maintained.
2. Note the registration number and details of any smoky vehicle to report.
3. Try to increase your number of car free days.
4. Avoid short journeys by car.
5. Keep your car out of town centres on sunny summer days.

Another example of a local initiative aimed at managing local demand of transport is Hampshire County Council's "*Headstart*" Campaign. This campaign has been running for two years and follows the basic strategy of raising Awareness, gaining Acceptance, and changing Attitude to achieve action. It is recognised that the strategy will see few short-term effects but relies on a longer term view. Equally it is noted that the campaign alone will not provide the whole answer to the transport dilemma but it is hoped that with complementary measures (see above) it will illustrate the alternatives to the private car. The programme is a local authority initiative to ensure that public transport is not unfairly disadvantaged, and aims to change the modal share of transport and encourage a more sympathetic use of the private car.

The main thrust of the campaign has been to raise awareness amongst the communities of Hampshire through the comprehensive Community Involvement Programme (run through Local Agenda 21) of the growing transport problems and the part they can play in achieving a solution. Specific activities carried out under this scheme include[17]:

- The Council's development of a staff transport plan to encourage a more sustainable use of transport and has been approached by employers and chambers of trade keen to contribute to the development of the ideas.
- The development of a school transport plan together with a local school which it is hoped, will form a model for other schools to follow.
- The use of CD-ROM aimed at providing varying levels of guidance to potential users such as community workshops, the aim of which is to support and develop a greater depth of understanding of the transport debate.

In addition to providing a public awareness campaign, the *Headstart* programme itself has been adopted for use in developing a process through which integrated transport strategies, which rely heavily on the need to identify sustainable and acceptable solutions to local problems, can be formulated.

The statement of intent surrounding the future direction of this policy can be found in Hampshire County Council's Internet site which stated that:

[17] Hampshire County Council http://www.hants.gov.uk/environment/headstar.html, 1997

The community involvement in "Headstart" has been the key to raising the profile of transport issues around the county. It is proposed to further develop Headstart in the coming year by increasingly involving the communities of Hampshire in their own solutions to the transport problem and by actively encouraging schools and businesses to participate through transport plans and technological innovation. This will be backed up by a high profile awards scheme for the best community contribution. Hampshire will continue to work together with other authorities in order to provide a holistic approach to the issues which cannot alone be resolved by individual authorities.

Monitoring the success of the program will be an important aspect of the initiative and this will be built into the development of transport strategies and policy monitoring processes.

5.6 Summary and Conclusions

Reflecting its history, the UK National Air Quality Strategy essentially takes the standards based, regulatory, and single pollutant approach traditionally used in controlling industrial emissions, and combines it with the local emphasis developed around local authority (or groups of local authorities) boundaries, through the concept of smoke control areas. However, the shift in the Act of standardising measures under taken under smoke control legislation and extending them to include new air pollutants to create a more unified approach to local air quality management is significant. It reflects the need to standardise approaches promoted in the EU directive (Commission for the European Communities 1995).

Indeed, while the UK National Air Quality Strategy can be seen to be an attempt to foster a more integrated approach to local pollution problems and an initial recognition of the road transport derived nature of many of these pollutants (Longhurst, Lindley et al. 1996), it can also be seen to be a quick response to European air quality legislation and essentially integrates the European directive into UK legislation (compare the principles of the UK National Air Quality Strategy, with the requirements laid out in the directive). Beyond establishing a framework for local action the strategy itself produces little new in the way of new approaches to air pollution at the national level beyond the introduction of fiscal disincentives for car use and tightening of emission standards, and in this context can be seen to be a reinterpretation of the BATNEEC and smoke control areas, which are traditional in the area of environmental policy.

The Strategy itself produces little in the way of direct national government policy beyond raising duty on fuel, increases in road tax and privatisation on the public rail network (section 5.2), all of which have been linked to an economic agenda rather than air quality (Burke, 1997) and have been criticised for their ineffectiveness in reducing private transport usage (Air Health Strategy February, 1997), the reasons for this are explored in chapter 7.

Beyond, this the strategy simply reiterates the government's intention to implement European directives on emission controls, promote low emission fuel technology and introduce a series of legislative standards and guidelines which are aimed at promoting air quality as an issue within local development. This latter move is essentially a contextualisation of the 1995 Environment Act (part IV).

At the strategic level the developing approach to the management of air quality in the UK is essentially a multi-tiered top-down approach (see Figure 5.1), based firmly within the regulatory control of lower levels of management by the upper ones (Bate, 1994). The relationship between both levels of government and the public is based within the welfare paradigm with respect to social and environmental legislation in the UK (McAuslan, 1980), this is the paradigm that has dominated the relationship between government and the population through the last couple of centuries.

The relationship between central government and European legislation is, however, slightly different: while directive implemented standards can be seen to be a control mechanisms requiring a standardised response by national government to European management objectives, there is a strong input into the setting of objectives by the national governments that are effected by them. This representation is derived through the concept of subsidiarity implemented through the co-operation procedure (illustrated in Chapter 4.2).

The 1995 Environment Act itself can be seen as set legislation act with the aim of imposing local air quality standards on local councils for specific pollutants, namely NO_2, SO_2, Benzene, Pb, CO, 1.3 butadiene and PM_{10}. Tropospheric ozone was at first also included in the Act but later ratified in the Strategy as a substance with set guidelines, with associated information and alert values, but without the legal requirement of air quality management designation in areas where standards are exceeded (Air Health Strategy, September, 1996).

The approach of the Act is essentially to impose the EU directive on Ambient Air Quality Assessment and Management into UK onto the remit of local authorities (albeit prior to the implementation of the directive), where the concept of *Air Quality Management Area* can be seen to be equivalent to the European Union designation of *Area of Poor Air Quality.*

The nature of the developing framework for air quality management can essentially be seen as one which is based on control strategies set out by central government, in the form of standards and set guidelines, which have the aim of exerting a certain amount of control over the lower tiers of government as the minimum action they are committed to in order to realise the central governments perceived aims for air quality management.

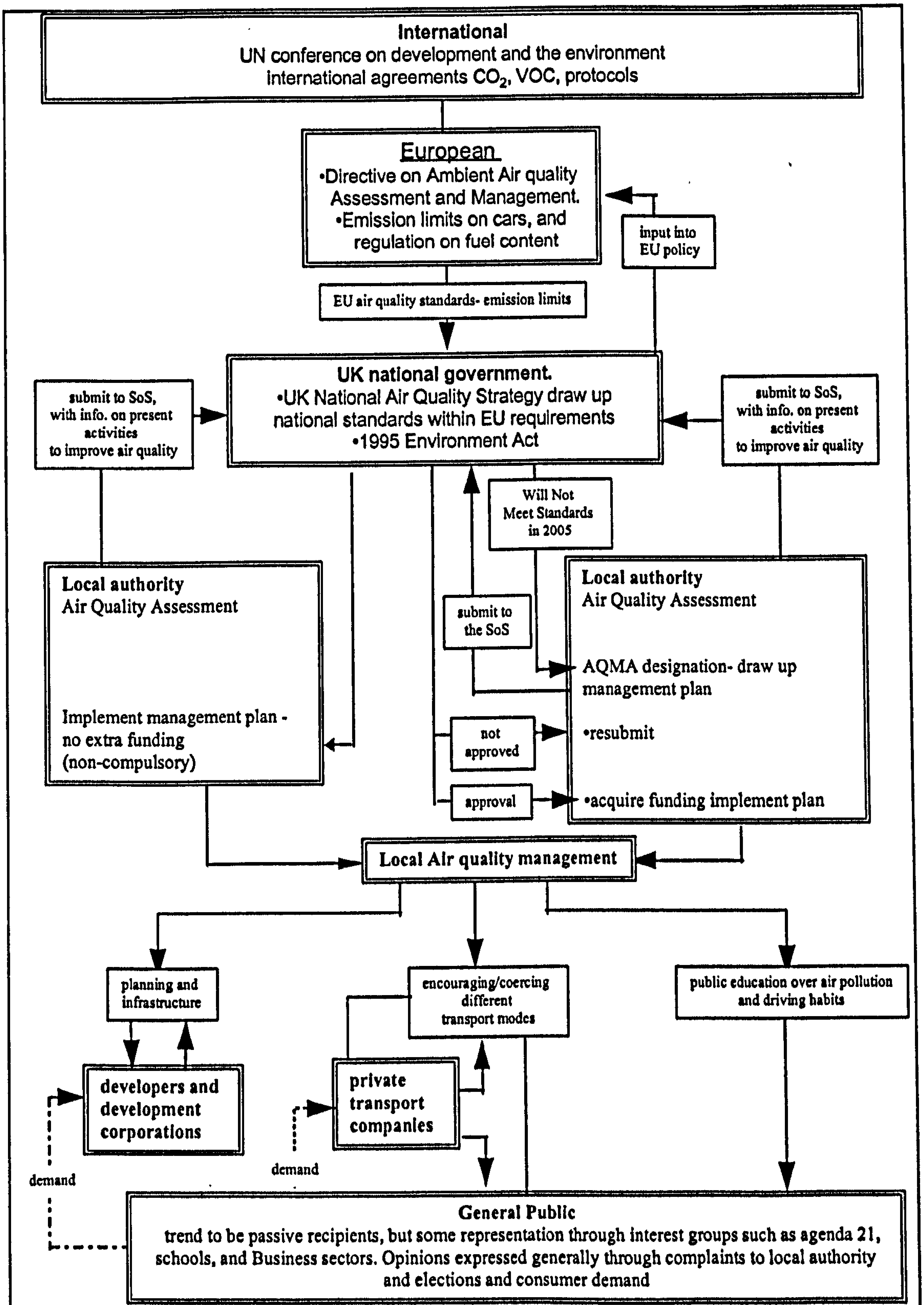

Figure 5-1: Schematic of the UK Air Quality Management Framework

What constitutes an air quality management issue is emerged over the last two years through government statements and associated research agenda, is defined as exceptional areas of localised pollution hot-spots which are not expected to meet threshold standards by the year 2005 (Air Health Strategy July, 1996; Air Health Strategy February, 1996; Air Health Strategy December, 1996; DoE, 1997). The number of these areas are expected to be very low. However, this view is not shared by many local authorities familiar with local conditions (Air Health Strategy April, 1996).

While it has been noted by the DoE, that local authorities are expected to respond to air quality issues without being designated an air quality management area, the development of management plans in such areas will be left to the discretion of the local authority. These are, however, constrained by tight budgets and have been shown to illustrate varying degrees of political will (Cannibal and Hadfield, 1997), producing what can be seen as great inconsistencies in approach to both monitoring and particularly important in the case of tropospheric ozone, air quality and traffic management throughout a multiple authority region (Hadfield, 1994), see Chapter 8.

The 1995 Environment Act can be seen as being essentially a starting point for the management of local hot-spots in that it may focus local authorities on the issue of such air quality management, and the importance of integrating environmental and development policy in plan making. However, another side to the Act is the recognition that in the case of more dispersed regional pollution events it has little to offer, especially if there is a great distance between cause and effect or where air quality is generally perceived by the public to be poor but is has not been identified as exceeding government guidelines. This point is illustrated by the dropping of ozone as one of the pollutants whose presence over set limits would qualify an area for AQMA designation (Air Health Strategy September, 1996; DoE, 1997).

The role of the local authority in the strategy can be seen as one of liaising with local developers, transport companies and the local population to encourage development and road usage types that can meet air quality standards. The way this is being implemented also reflects the history of local authority action, since the approaches reflect the traditional planning and development functions of a local authority in combination with the role local authorities have had in environmental health (itself a product of their initial role in ensuring housing provision and sanitation, see Chapter 4).

The approach to infrastructure provision at present is still very much that of the plan-based system that has dominated local authority economic development over the last half century. However, this system has been weakened by a move in the 1980s from regulation to enablement with regards to this function and a general growth in the role of private capital and development corporations in many areas (Brindley, Rydin et al. 1989). In addition to this feature, transport planning is a generally segregated business with the central government being responsible for major trunk-roads, county authorities being responsible for roads and transportation outside urban areas and local authorities being essentially responsible for urban road networks (Pas, 1986). This situation was complicated by the deregulation of public transport provision in the 1980s, as is illustrated by this quote from a local authority engineer:

Another very important issue there is a push to integrate transport/land-use and the environment but this is not consistent with other policies for example privatisation, over which I have no personal ideological views -but it does need regulation. For example bus deregulation promotes the use of commercial routes at the cost of closing non-commercial, the efficiency of public transport is now measured in terms of purely financial efficiency.

Recent shifts such as the establishment of unitary authorities and giving councils a greater roles in development policy have tried to approach some of the issues surrounding this segregation, however, it is generally recognised that local authorities face many constraints in controlling infrastructure and economic development (DoE and DTP, 1993). This feature was bluntly expressed in the interview with Bedford Borough's Planning Policy officer and the Borough Engineer (1996):

***(interviewer)** Does this rise of private influence hinder the local authority in providing alternative to the private car.*

***(Planning Officer)** Local government now only produces plans, we are enablers, we don't do anything about it.*

These issues are dealt with further in chapter 8.

The other major role of the local authority in the present framework for air quality management is that of changing public behaviour with reference to the present use of the motor-car (Longhurst, Lindley et al. 1996; DoE, 1997).

Detailed monitoring of air pollution is generally carried out in areas where, under the DoE standards, the air quality is expected to be poor. Beyond this, more generic or simulated air pollution models are expected to be used. Information given to the public tends to be either via a local telephone hot-lines or on the Internet (both of which are active media, i.e. they need the recipient of the information to take the initiative to find it). Air quality bulletins have been criticised since they tend to represent air quality in as good a light as possible. These bandings have been used to offset or even discredit local perceptions of poor air quality when *satisfactory* bandings recorded through monitoring. However satisfactory bandings may be recorded even when air quality may prove a threat to health.

Furthermore monitoring is generally being used to identify pollution hot-spots at fixed locations. However these hot-spots are not in themselves fixed and respond to changing patterns of transport, through for example air quality management programmes. In addition to this the location of fixed monitoring and hot-spots do not coincide with the location of people. Monitoring of personal exposure has been recognised as an important feature (Air Health Strategy May, 1996), but the approach has been rejected by the DoE (Air Health Strategy December, 1996; Air Health Strategy February, 1996; Air Health Strategy November, 1996). This features are especially relevant when one remembers that it is widely recognised that most current air quality legislation has come into being either directly or indirectly as a product of public concern (Ashby and Anderson 1981; DoE 11/1996 1997) and that this public are the drivers whose behaviour needs to be changed (this issue is extended in depth in chapter 8).

The present approaches being developed to changing travel behaviour are mainly based on the premise of information provision and education through public awareness leaflets. Public participation exercises tend to be carried out with interest groups and local agenda 21 groups. The approaches developed by authorities are new and it is generally accepted that they have uncertain outcomes and therefore need to be monitored closely (Hampshire County Council, 1997[18]; DoE 1997[19]). However, this fact has not stopped them becoming what are essentially generic approaches adopted by other local authorities. For example the *Travelwise* campaign first developed by Hertford County Council has now been adopted by over thirty local authorities, including Bedfordshire County Council.

The essentially ambivalent nature of the wording of the Act and the UK Air quality strategy as to the role of the public in air quality management reflects what is shown in much of the legislation and guidance emanating from central to local government and mirrors the public welfare ideology traditional to UK policy (see chapter 4), where the public are essentially seen as recipients of policy or education programmes which are drawn up on their behalf by a "*distant authority*" (McAuslan, 1980), through guidelines resulting from generic or studies carried out in distant locations, with very little input from the public involved. This point raises the worries over the consistency and applicability of public involvement exercises (as noted in chapter 4).

The suitability of the framework presented in this and the preceding chapter for the management of one of the major problems for air quality management, tropospheric ozone. The nature of this pollutant will be discussed in following two chapters. These next chapters will illustrate that this pollutant is a disperse social and biophysical problem that shows variation in its both the qualitative and quantitative issue set in different locations throughout the area of its source to reception.

[18] Hampshire County Council http://www.hants.gov.uk /environment/headstar.html 1997

[19] DoE http:// www.open. gov.uk/dot/tpu/tai.htm, 1997

6. Tropospheric Ozone: A Regional Problem

Chapter 3 described some of the recent theoretical developments in how ozone originates from its precursors and how these are transported and transformed down wind from large densely populated areas, accumulating in rural or suburban areas down wind. The chapter also illustrates with reference to North American and Canadian locations the features of spatial and temporal variation inherent to this pollutant.

Using empirical data collected from secondary sources over the years 1992 - 1996, this chapter will compare the pollution profile of identified ozone rivers in North America and Canada with that in the area to the north west of London in the UK. It will illustrate the regional nature of the problem and the way it shows itself as different issues at different spatial and temporal scales.

6.1 Introduction

Recent research has shed much light on the nature of tropospheric ozone events, how this substance is generated from its precursors, and the effect that relative variations in precursor background values, wind direction and sunlight intensity can have on concentrations in areas that are subject to high ozone values.

The main features of how ozone is generated and received include the following (Chung 1977; Kankidou and Crutzen 1993; McKendry 1993; Bower, Stevenson et al. 1994; Chameides 1994; Wolf and Lioy 1980):

- Ozone is generated downwind from urban areas of high traffic density, and forms in areas where background emissions of precursors are low. It generally forms an urban plume impacting on more rural areas, forming the phenomenon that has come to be known as an "*ozone river*".
- Ozone generation, dispersion and impact may take several hours and while the substance may persist for many days, it is readily scavenged by nitrogen oxide resulting from short term emissions in areas where background levels of NOx may be generally low (for example during rush hour traffic).
- The optimum period for ozone formation has been identified as being about 3- 5 hours and production generally occurs at low level wind speeds of about 4-5 ms^{-1}. Peak ozone resulting from urban precursor emissions therefore generally occur 50-60 km downwind of the source.
- Ozone formation depends on the ratio of background concentrations of pollutants.

The mechanisms responsible for these features of ozone formation also produce the following temporal effects,

- Strong inverse diurnal variations between ozone and NOx, where ozone has high afternoon peaks and smaller night time peaks;
- Strong inverse seasonal variations of ozone and NOx, where ozone has high summer peaks;
- Ozone episodes tend to be associated with persistent anticyclonic episodes, typified by low wind speeds and warm temperatures; and

- It shows strong annual variations in concentrations depending on the frequency of these synoptic weather conditions.

The consequence of the chemical dynamics involved in ozone formation is that ozone rivers tend to form complex regional patterns over differing scales (Kankidou and Crutzen, 1993). For instance it has been shown that in the area north west of Montreal, although peak ozone concentrations are associated with mild south easterly winds and precursors originating in the Montreal region itself, a larger scale ozone river can also be detected originating from the highly developed north eastern area of the USA, which has been identified as important in producing elevated background ozone concentrations found in this area (McKendry, 1993).

However, ozone pollution regimes that can be attributed to these sort of multi-scale spatial patterns produce distinctive features and the presence of these distant effects can be identified by comparing pollution profiles of different areas with those found in areas where ozone rivers have been identified by statistical and atmospheric modelling (McKendry 1993).

In addition to these features, some of the accepted findings from the epidemiological and toxicological literature on how this substance impacts on human health have also been described (chapter 3.4). It is noted that health effects may be associated with both repeated exposure to short period high concentrations, below 15 minutes (Lippmann, 1993) and to long term exposure of relatively low concentration (Allen, Foley et al. 1993; Elsom, 1996). Furthermore significant economic damage due to crop yield reduction may occur at levels of 40 ppb (Runeckles and Bates, 1991). Management strategies need also to consider that the issue of ozone is often expressed as an issue of general air quality (Hadfield and Cannibal, 1996), a point typified by the Department of the Environment's air quality forecasting methodology[1] that expresses local air quality bulletins in terms of air quality bandings very good, good, and poor.

6.1.1 The Study Area.

The study area of the thesis is centred around the Borough of Bedford and the surrounding area of south central England, defined by a recognisable biophysical air flow in the form of an ozone river[2].

The Borough of Bedford was first defined in the local government reorganisation of 1974 and covers an area of 11,595 acres, taking in the towns of Bedford, Kempston and 43 rural parishes. The overall population is 137,000 of which 92,000 are resident in the urban areas of Bedford and Kempston. The Borough is defined as a semi-urban environment (Sweeny, 1993). The economy of the area relies on light industry

Bedford is located to the north-west of London (45 miles) and lies south-east of Birmingham (65 miles). It is also in close proximity to two major north-south routes, the M1 (10 miles) and the A1 (6 miles). To the south and east are the M25 (London orbital motorway) and M11 motorway (see Figure 6.1).

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[1] DoE (1997) http://www.aeat.co.uk/netcen/airqual/*.html

[2] see chapter 2 and glossary

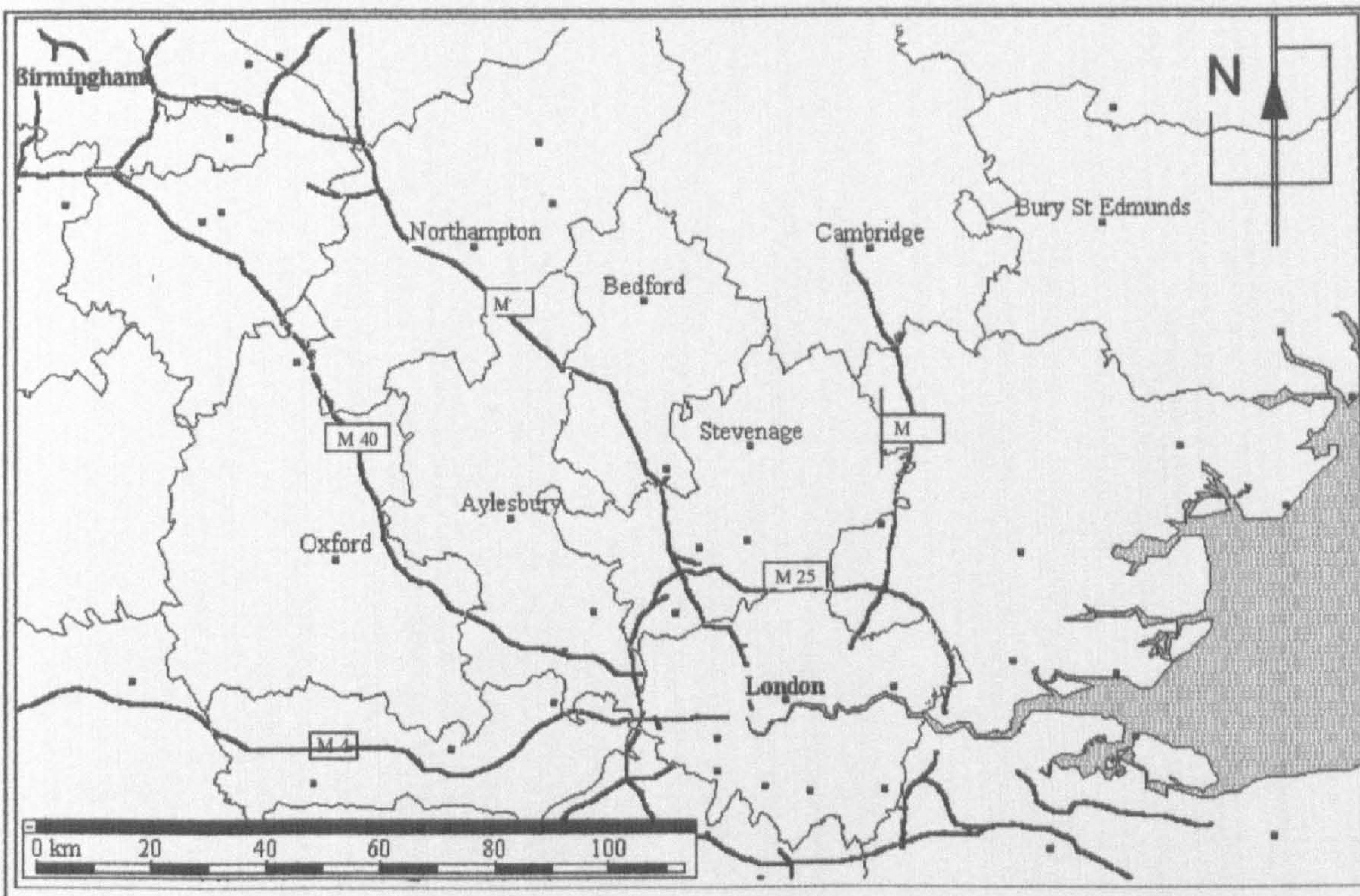


Figure 6-1:. The south central area of the UK

Over the last few years there has been growing concern about the ambient levels of tropospheric ozone in the Borough of Bedford (Bedfordshire on Sunday, 1994; Sweeny 1993; Bedford Borough Council, 1995), a concern that was highlighted by a report commissioned by Bedford Borough Council between the 7th June 1993 and 10th September 1993 (Sweeny, 1993). This noted an early season peak in ambient ozone concentration (171 ppb[3] on 8th June 93) well above possible thresholds capable of causing short term reduction in lung function (Walters 1994)[4]. Furthermore there were numerous cases during this period where EC threshold limits were exceeded and DoE "poor" criteria[5] were achieved. Results for 1994 indicate that five "ozone episodes" occurred during the period of measurement (June-August), with a maximum of 127 ppb, which was the highest hourly average concentration measured in the UK.

Although these levels were lower than many rural areas, they were high for an urban area, in fact higher than any of the other seventeen national ozone monitoring sites in all three years. Meteorological analysis indicates that winds from the south east were associated with the highest concentrations.

[3] parts per billion

[4] see chapter 2

[5] see chapter 3

In light of this report it may be proposed that Bedford's tropospheric ozone levels represent a possible health risk due to the concentration levels experienced in this area as well as the relatively high population density and there is distinct local concern (Bedfordshire on Sunday, 22 Jan 1995). However under the regime of the 1995 Environmental Act (DoE, 1995) it is unlikely that Bedford would qualify as an "Air Quality Management Area (AQMA)" since no other pollutant qualifies for this designation in the area and ozone, while having set standards is noted as being exempt from regulations surrounding AQMA designation (DoE, 1996)[6].

6.2 Aims

Comparing the features of ozone rivers identified in the work carried out in Ontario and the United States (Chung, 1977; Wolf and Lioy, 1980; Chameides, 1994; and McKendry, 1993), the aims of this chapter are to illustrate how these recognised features in ozone chemistry may reconfigure in the south central area of the United Kingdom and outline the implications they have for management of the pollutant in this area.

Using available secondary data to illustrate the biophysical nature of the system, the chapter has the following aims:

- To illustrate how different air quality measurements may under-represent pollutant concentration over short time-periods in locations where the pollutant may be a problem;
- to illustrate the temporal and seasonal variation in ozone and its precursors in this area;
- to demonstrate the likelihood of a London to Bedford ozone river; and
- to illustrate the possibility of the presence of multiple scale source receptor relationships in this area.

6.3 Method

This chapter draws on secondary data collected from paper sources from local authority environmental health departments and world wide web pages covering both the NO_2 diffusion tube survey and the Automatic Monitoring Network run by AEA (incorporating NETCEN) on behalf of the Department of the Environment (see appendix 2). The data has been collected using a range of techniques from different sources (Table 6.1) and is used on a "what is available basis".

Climate data was made available through the British Atmospheric Data Centre (BADC) and takes the form of hourly readings for wind direction, surface air temperature and wind speed for the London Heathrow Met-Office Station.

The air quality data sets used in this investigation have been generated by different bodies using different methods (a review of which can be found in Table 6.2). The continuous samplers tend to be expensive and are therefore used where in-depth pollution data is deemed necessary or for short periods to identify areas that may need more consistent monitoring using diffusion tube surveys (DoE, 1997).

[6] see chapter 3

The passive (i.e. non automated samplers) are cheaper but depend on manpower to oversee and analyse them. They are more commonly the tool of local authorities.

Table 6-1: Summary of data sets used in this review

Local Monitoring Sites			
Location	**Pollutants**	**Years**	**Sampling Techniques**
Bedford Borough	Ozone	1994	UV Spectrometry
Bedford Borough	VOC	1996	Diffusion tube sampling
Regional diffusion tube survey	NO_2	1992 - 1996	Diffusion tube sampling
NETCEN data[7]			
Location	**Pollutants**	**Years**	**Sampling Techniques**
Stevenage	O_3 NOx, NO_2	1993	UV Spectrometry, Chemiluminescence
London (various sites)	O_3 NOx, NO_2 VOC	1992-1995 1996	UV Spectrometry, Chemiluminescence
Lullington Heath	O_3 NOx, NO_2	1993 - 994	UV Spectrometry, Chemiluminescence
Climate Data[8]			
Location (and duration)	**Factors**	**Years**	**Source**
London Heathrow 1 hourly readings	wind direction speed cloud cover surface air temperature	1993 -1994	British Atmospheric Data Centre

Caution must be taken over the mixing of these data sets especially between those taken by automatic monitoring sites and the passive samplers (Elsom, 1996) which have been known to show as much as a 10 to 20% variation in the pollutant recorded in the same location at the same time (Campbell, 1994). Furthermore, this variation is not consistent and therefore comparisons are difficult (Air Health Strategy, May, 1996).

Local authority data sets are designed to highlight local problems for air quality assessment and reviews with respect to individual pollutants named in the UK National Air Quality Strategy (UKNAQS), and are centred around DoE guidelines that promote a least cost approach towards identifying very localised hot-spots (see previous chapter).

The NETCEN data was originally set up to gauge general background limits in urban areas of concern for a set of pollutants which were being considered for UK and EU standards (DoE, 1994a; DoE, 1994b; DoE, 1995). However, under the 1995 Environment Act they have taken on the role of supplementing data requirements for local authorities with the aim of reducing the budgetary requirements of local authority

[7] DoE (1997) http://www.acat.co.uk/netcen/airqual/*.html

[8] BADC (1997) http://www.badc.rl.ac.uk/*.html

air quality assessment and reviews (Air Health Strategy 1996). The site descriptions of the NETCEN data is shown in Table 6.2.

It should be noted that the monitoring data was developed within the philosophy of the present air quality management system and is essentially locally oriented (see chapter 3).

Table 6-2: Review of data sampling methods

method	used for	time period	principle
Chemiluminescence	NO, NOx, and NO_2 (also used for O_3)	continuous	The principle of chemiluminescence is where light is emitted by a molecule at temperatures when it would not be expected by the introduction of a chemical reagent. For an NO, NOx and NO_2 monitor the substance used is ozone (or in the case of an ozone monitor ethylene). The amount of light emitted is proportional to the concentration of NO present. The sample is split into two air streams and the first is tested for NO and the second for total NOx (using a mobynium catalyst to reduce NO_2. Subtracting the first sample from the second gives the amount of NO_2
U.V. Photospectrometry	Ozone	continuous	The most common method used for ozone, uses the principle that ozone molecules absorb UV radiation at 253.7 nm. Ultraviolet photometeric instruments compare the amount of ultra violet radiation which is transmitted by ozone free air (generated by the monitoring instrument) and by the sample air. The instrument is calibrated by self generating known quantities of ozone.
Diffusion	NO_2, O_3, and VOC's	passive (three hour reading or more often monthly or weekly)	Consist of two stainless steel gauze discs situated in a down facing tube. These discs are then analysed out of situ in a laboratory using techniques such as photospectrometry. The main use of this data to date in the UK has been the AEA NO_2 diffusion tube survey.

adapted from (Elsom 1996)

Table 6-3: Site description

Outside London	
Lullington Heath	A small town near the Hampshire coast. The site itself lies on a high plateau 5 km from the south coast. Immediate area is a NCC heathland (closed 04/10/86)
Stevenage	A fairly densely populated new town lying to the north of London in Hertfordshire. The monitoring site is on the edge of a residential new town near a light industrial estate, 100 m east of A1(M) motorway. The surrounding topography is flat(closed 29/04/94).
London sites	
London Cromwell Road	An urban kerbside site. The monitor is located at the kerbside of a busy arterial road in Central London, where traffic density is approximately 60,000 vehicles per day.
London Bridge Place	An urban background site situated on the second floor office overlooking backstreet near Victoria Station.

6.3.1 Why this chapter is not a modelling exercise

In view of the lack of regionally co-ordinated UK air quality monitoring data this chapter is not, nor is it intended to be, an attempt in any way to model or prove a statistical relationship between pollutant source and impact. Rather this chapter will confine itself to illustrating how the behaviour of ozone and its precursors identified in modelling and empirical studies into ozone (e.g. McKendry, 1993; Chameides, 1994), may reconfigure into management issues in the Bedford to London area of the UK.

The reasons for this are that first and foremost, this study is concerned with the identification of a method for resolving the conflicting issues inherent in air quality management in the Bedford to London Region rather than aiming to model accurately regional air flows in this area. Therefore analysis of existing data sets to illustrate some of the issues that are present in this area is an adequate remit for this part of the thesis.

Secondly since air quality monitoring is extremely expensive and labour intensive (DoE, 1997), there are simply not the resources to carry out a comprehensive analysis of the regional pollution flows beyond the identification and summary description (indeed this in itself is a management issue, see chapter 8). For an empirical or statistical analysis to be reasonably accurate a model would require detailed data sets on regional and local climatic conditions, topography and ambient concentrations of the precursors (Chang and Rudy, 1993) specifically NOx and non-methane organic compounds (NVMOCs). These data sets, where they exist tend to be extremely expensive, of inadequate resolution, or have questions over accuracy. This problem is particularly relevant in the Bedford to London area where the air pollutants that have been monitored to a different extent for different reasons (Hadfield 1994; Cannibal, Longhurst et al. 1996; Hadfield and Cannibal, 1996) or in the case of the NMVOCs have not been monitored at all (Chang and Rudy, 1993). It is however recognised that research into these regional air flows and the qualitative relationships between the source and reception localities, including the relative role different locations play in the contribution to the source, is sorely needed and is a point identified as being an area for further research (see chapter 10).

6.3.2 An illustrative investigation into the regional air pollution issues.

The investigation takes the following approach:

<u>6.3.2.1 An investigation into the form air quality information takes and how it relates to actual levels at specific sites.</u>

The approach used is that of comparing real time data at 15 minute resolution from the NETCEN site at London Place when measured using different units of time relevant to the setting of air quality standards as well as identifying health effects (chapter 3.4).

<u>6.3.2.2 An investigation into the temporal variations in ozone and precursor concentrations in any particular area and the problems these give rise to in identifying exposure and management strategies.</u>

Using hourly variation and monthly average daily values in annual average ozone and NOx concentrations for the year 1993 in Stevenage and London Bridge Place, recorded by the NETCEN monitors, this section will demonstrate the degree to which the diurnal and seasonal variation in this pollutants (described in chapter 3.3) applies to different locations in the UK and how these translate into management issues in this area.

6.3.2.3 An investigation into the possible sources and impact issues inherent to this pollutant in this area.

This section will illustrate a variety of local issues in the London to Bedford area that arise from the qualitative and quantitative spatial variations in pollutant due to the way tropospheric ozone is formed (chapter 3.2). The implication that these local issues are actually part of a highly connected regional system is discussed with reference to the management of problems faced by local authorities in this area.

The aim of this section of the chapter is to illustrate how the identified flows of this pollutant and its precursors may be defined as air pollution management issues in the area from Bedford to London.

Since conditions for regional ozone generation tend to be large scale emissions of precursors and suitable meteorological conditions (QUARG, 1993), separating the influence of precursors and weather in ozone formation can give some insight into the source and size of these pollution flows (McKendry, 1993). It has been noted (QUARG, 1993) that an index of wind speed and wind direction can be usefully employed to represent synoptic anticyclonic weather conditions that contribute to the production of ozone.

The sites chosen were Lullington Heath, London Bridge Place and Stevenage since these sites represent a general SE to NW transect across the south east area of the UK for which concurrent and high resolution ozone data is available. Using this data set and comparing it to levels recorded around Montreal and Ontario (Chang and Rudy, 1993; Huess and Wolffe, 1993; McKendry, 1993; Chameides, 1994) this section of the study will illustrate the regional nature of the pollutant in terms of its possible origins and spatial relationships.

6.4 Results

6.4.1 A Note About Air Quality Standards

Figure 6.2 shows three different measurement standards for tropospheric ozone concentrations measured at London Bridge Place. These are hourly mean; the maximum 15 minute daily peak; and the running 8 hour mean (the measurement used in UK O_3 air quality standards).

While it is recognised that health effects are initiated by short term peaks (section 3.4) these are not picked up when measuring running 8 hour means. For many days where ozone air quality reading expressed as an 8 hour mean falls within the UK government's "good" standard and long term aim of 50 ppb (DoE 1997) there are accompanying events where the short term 15 minute peak may well pose a threat to local health (e.g. mid June, early July and the 7th, 17th & 29th of August).

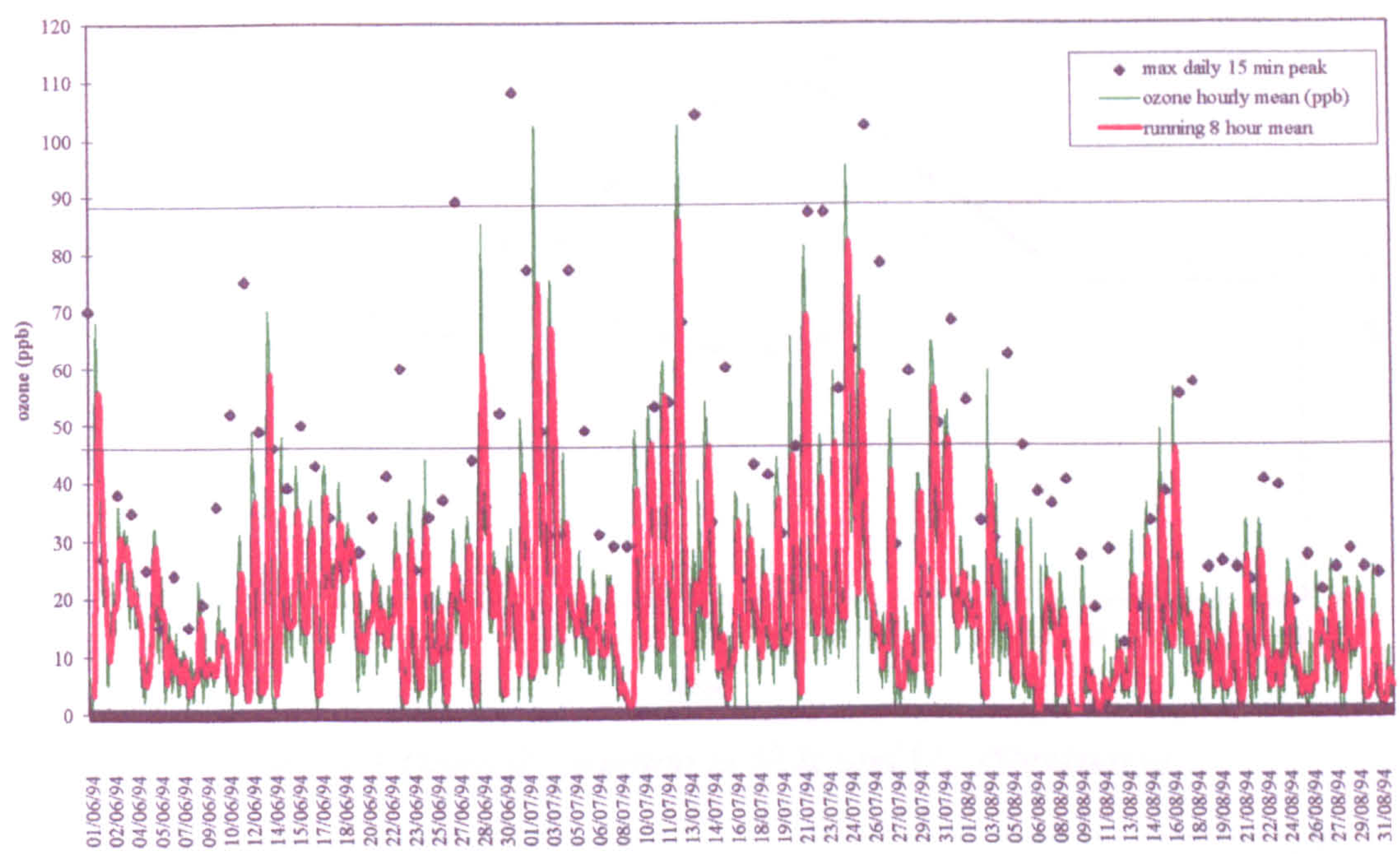


Figure 6-2: A comparison of O_3 measurements using hourly mean, 15 minute peaks and 8 hour running means (from London Bridge Place 1994).

6.4.2 Temporal Variations

6.4.2.1 Diurnal variations

It has been noted (section 3.3) that a feature of ozone events associated with urban plume ozone rivers is the strong diurnal variation in the concentration of this substance as local transport derived NOx feeds into the system and is dispersed or scavenged by ozone resulting from down wind air flows formed under the influence of sunlight.

Figures 6.3 and 6.4 show the hourly variation in annual average ozone and NOx concentrations for the year 1993 in Stevenage and London Bridge Place recorded by the NETCEN monitors.

There are distinct peaks in NOx concentrations in the morning and early evening, While ozone peaks occur in the afternoon and very early hours of the morning. Thus the local NOx and O_3 concentrations show a more or less inverse relationship, a feature which is apparent in the Bedford to London area.

These peaks correspond to those recorded by McKendry (1992) and Chameides (1994) who have related them to periods of rush hour traffic. NOx concentrations are then depressed during the afternoon period when solar intensity is at its highest, and therefore most ozone production occurs. The trough in NOx is related to both ozone scavenging and NOx dispersion (McKendry, 1993; Chameides, 1994). The second peak in O_3 has been attributed to wind dispersion of NOx (resulting in less scavenging) and by suppression of the boundary layer allowing downward migration of stratospheric ozone (Chameides 1993; Chung 1977).

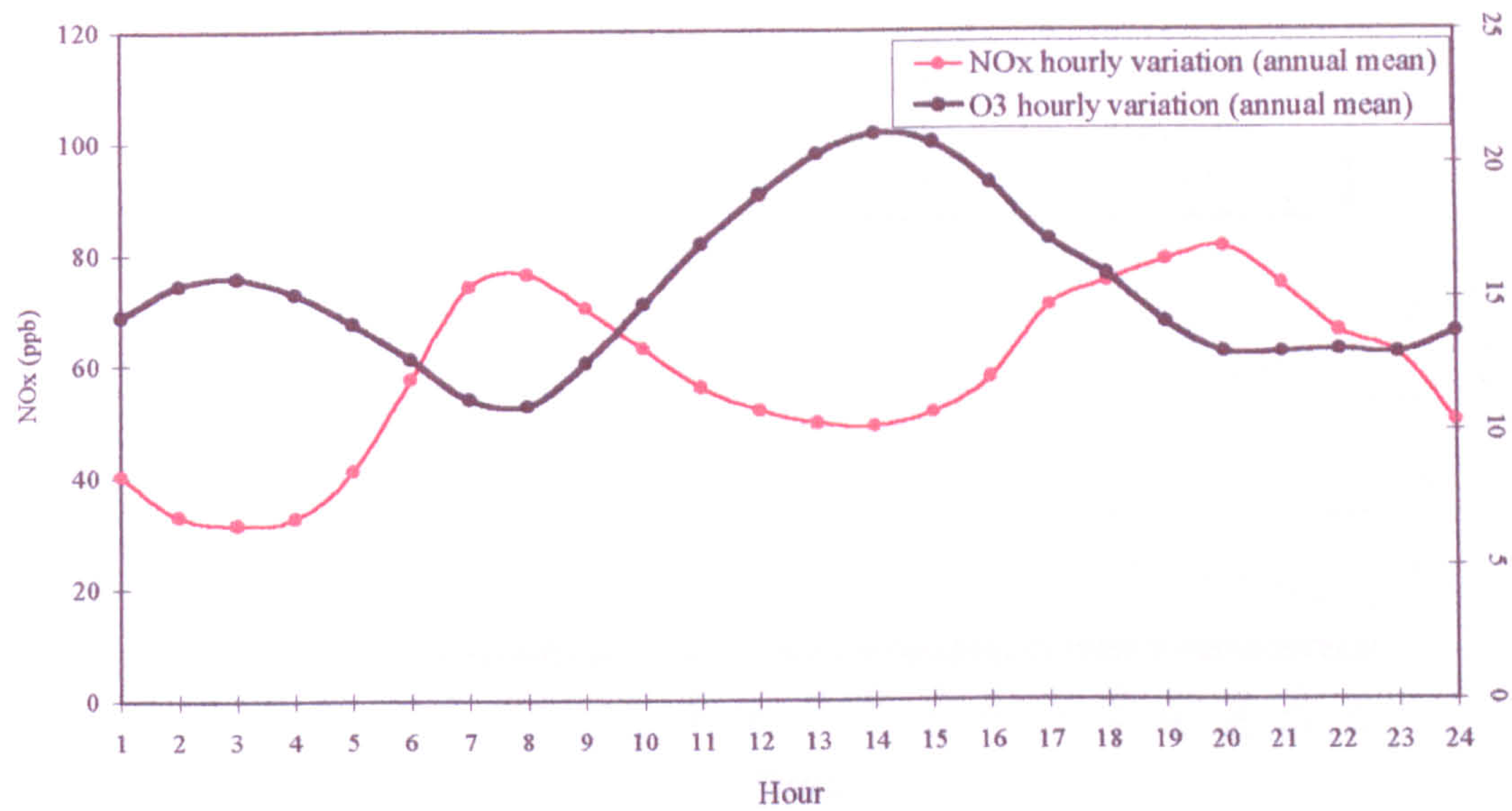


Figure 6-3 Diurnal variation in NOx and O_3 (Stevenage)

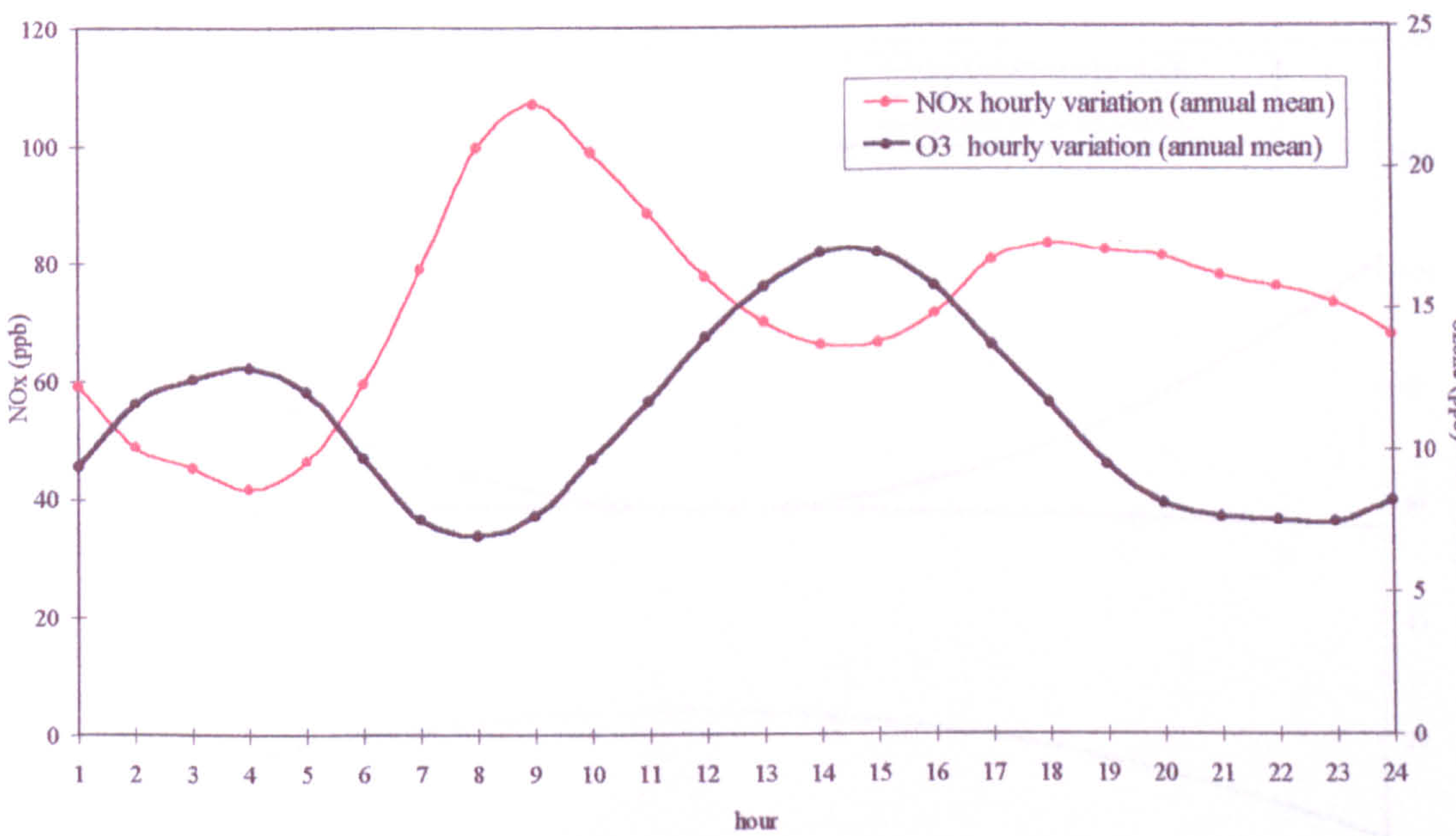


Figure 6-4 Diurnal variation in NOx and O_3 (London Bridge Place, 1996)

6.4.2.2 Monthly variation

Figures 6.5 & 6.6 show the trends (2nd polynomial) for NOx, NO_2 and O_3 for Stevenage and London Bridge Place. Notable points here are the distinct variation from summer to winter in NOx and the inverse trend in ozone concentration. Nitrogen dioxide on the other hand shows little seasonal variation. The results are consistent with those found by McKendry (1993) in the Montreal Region, by Chung (1977) in the Toronto region and by Wolf and Loiy (1980), in the Eastern United States.

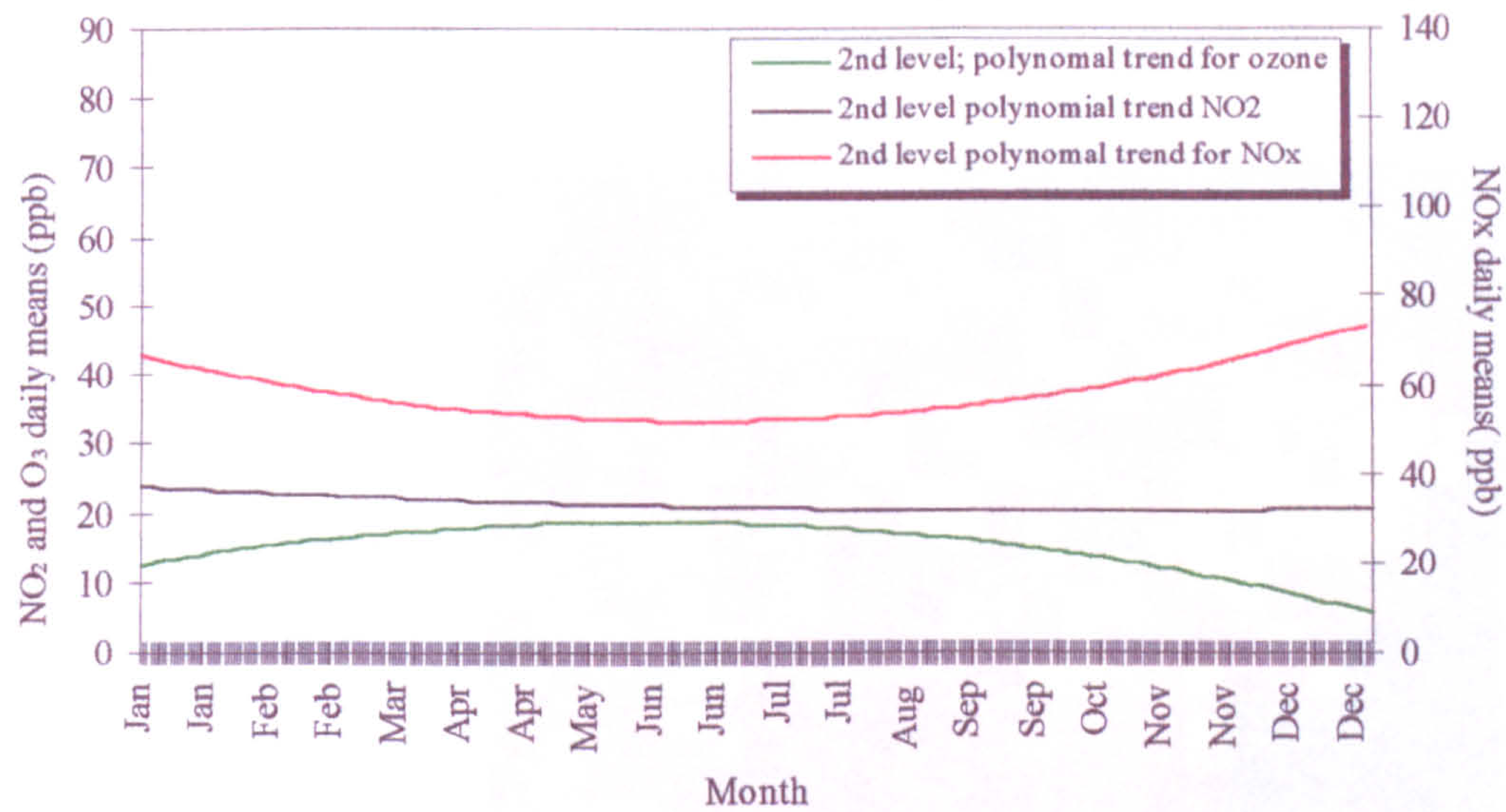


Figure 6-5: Seasonal trends associated with NO_2, O_3, and NOx in Stevenage

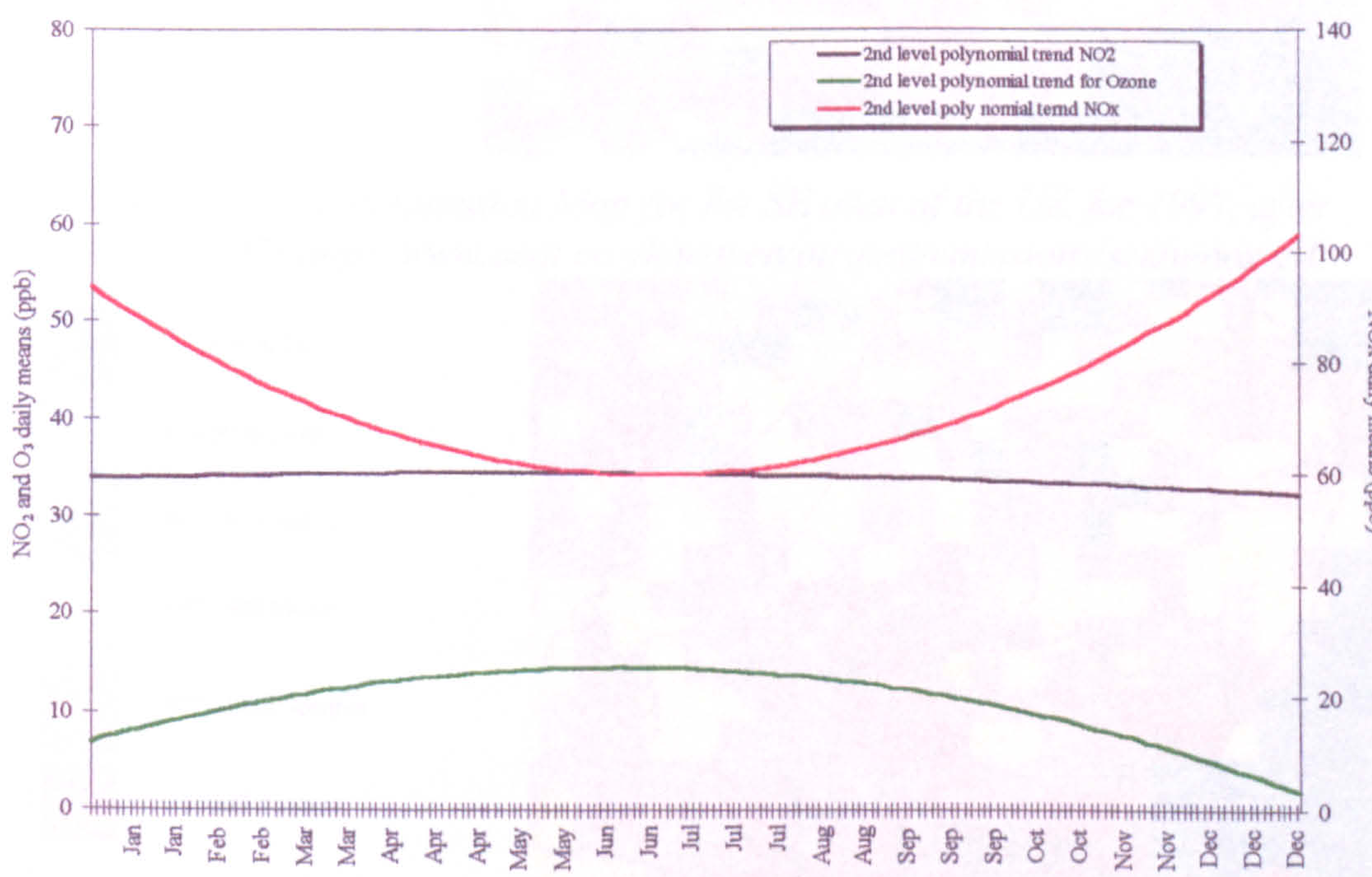


Figure 6-6: Seasonal trends associated with NO_2, O_3, and NOx in London

6.4.3 The Spatial Nature of the Biophysical System

This section of the investigation will illustrate the spatial nature of these regional pollutants and how they relate to each other, covering the emission, transportation and reception of ozone and its precursors in the south central region of the UK.

6.4.3.1 Background Emissions

Figures 6.7 and 6.8 show the estimated emission inventory for the south eastern corner of the UK for the year 1995[9].

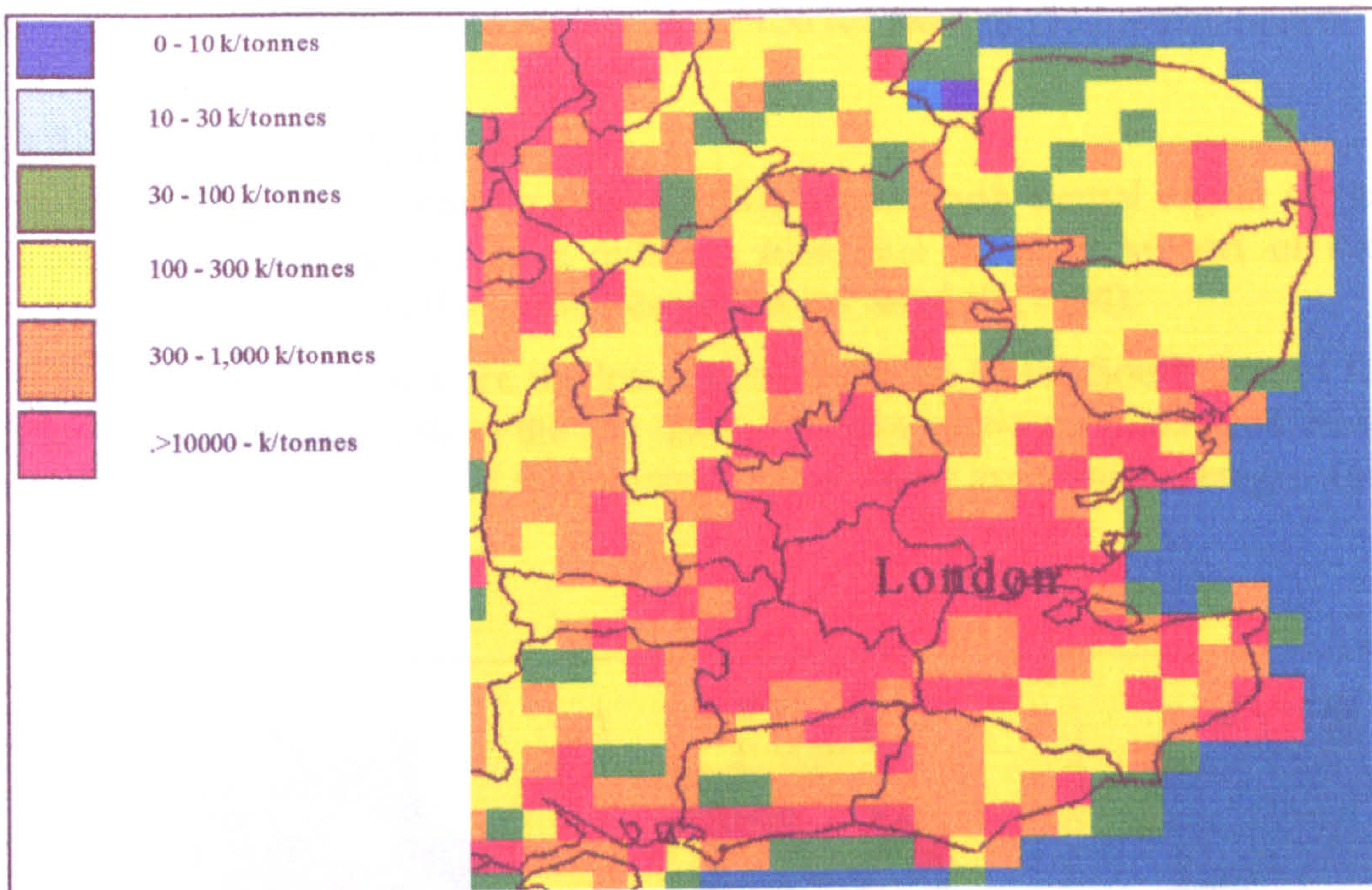


Figure 6-7: NOx Emission Map for the SE area of the UK for 1997, after DoE (1997) http://www.aeat.co.uk/netcen/airqual/emissions/seengnox.gif.

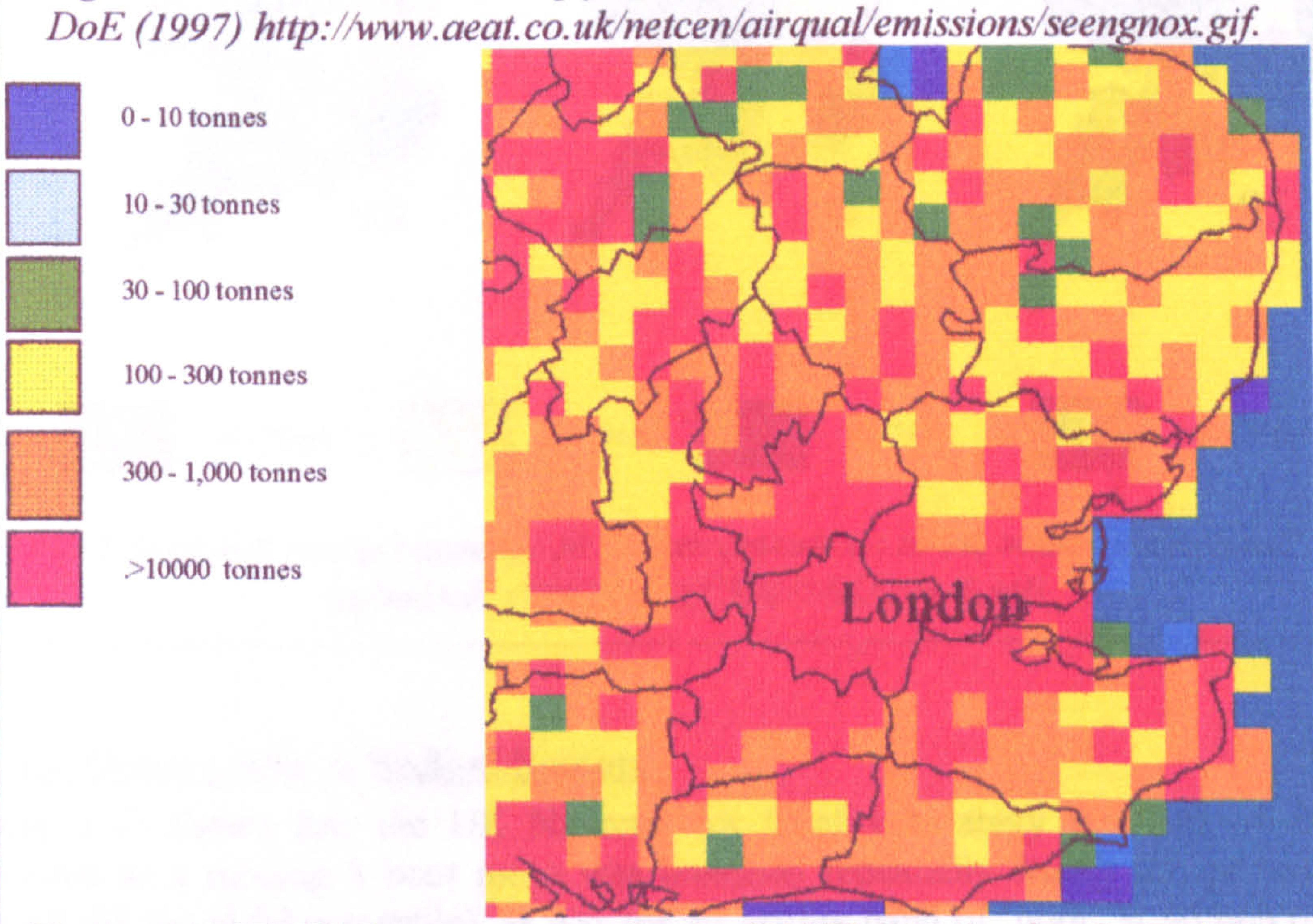


Figure 6-8: NMVOC emission map for the SE UK (1995), after DoE, (1997) http://www.aeat.co.uk/netcen/airqual/emissions/seengvoc.gif

[9] DoE, (1997) http://www.aeat.co.uk/netcen/airqual/emissions/*.html

Figure 6.7 identifies London as a main source of NOx in this region with low or intermediate emission to the NW and SE. The region of high emission running from London to Birmingham corresponds to the location of the M1 motorway.

Figure 6.8 also identifies London and the M1 as a main source of NMVOC but notable is the difference in the scale by a magnitude of 100 for most of the London region.

6.4.3.2 Background NO_2 profile

Figure 6.9 shows a concentration map for NO_2 in the south central region of the UK. Concentrations were derived from diffusion tube data gathered as part of the NO_2 diffusion tube survey using the method described in Campbell (1994).

Notable points of this figure are the lower concentrations to the South East of London and the raised concentrations in the city itself. The area between London and Bedford is intermediate. It should be noted that numbers in this figure are annual averages and in no way reflect temporal fluxes.

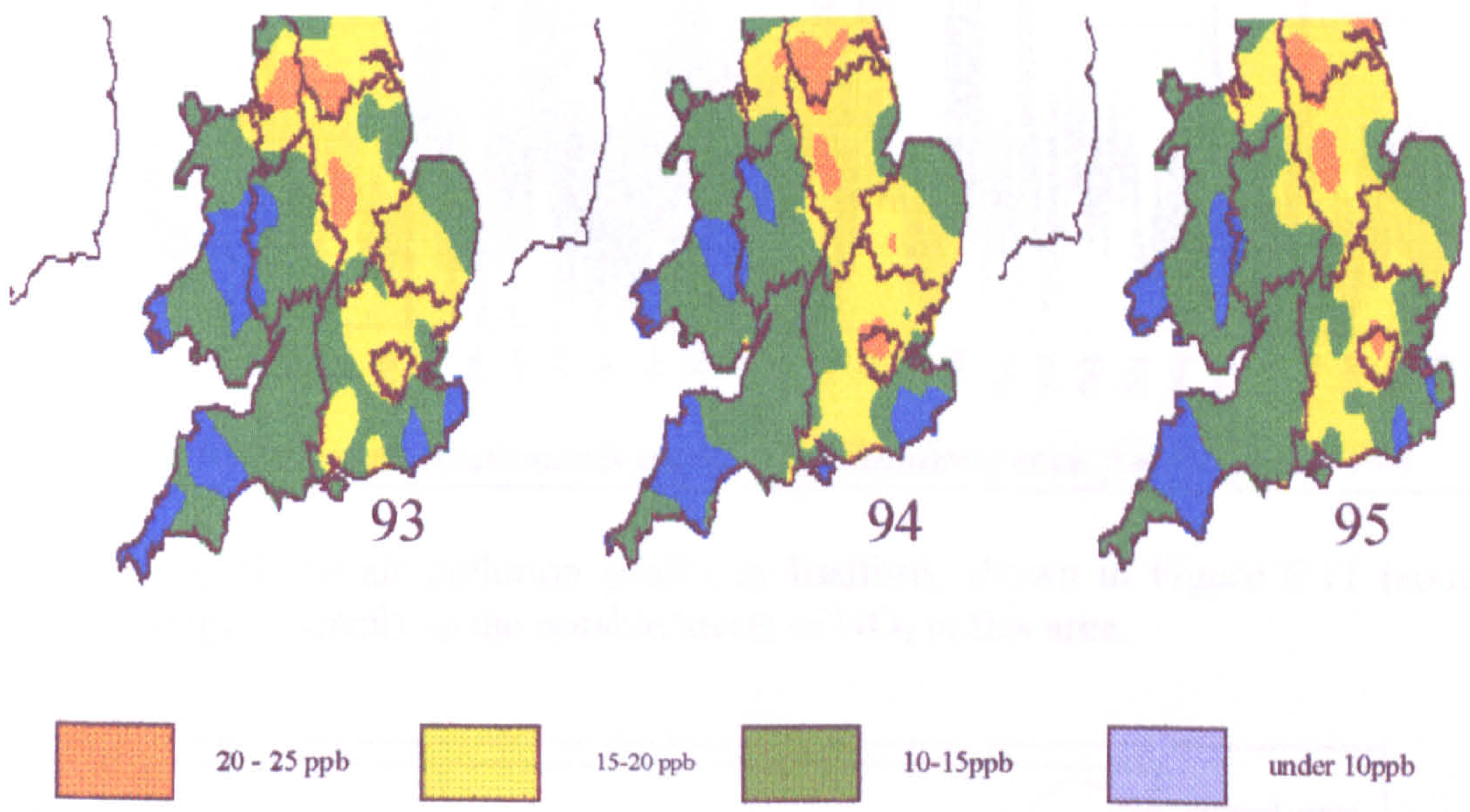


*Figure 6-9 annual average NO2 concentrations in the south of England (afterDoE (1997) NETCEN */NO293-5.gif).*

6.4.3.3 Ozone profile of Bedford Borough

Figure 6.10 shows that the UK National Air Quality Strategy standard of 50 ppb measured as a running 8 hour mean was breached repeatedly during this period (well beyond the stated 97 percentile), as was the air quality band of 'poor' at 90 ppb running 8 hour mean (Stacey, 1994). These figures were higher for 1 hour mean results (the maximum resolution of the data) and therefore tropospheric ozone levels fall outside the UK desired range and may well be injurious to both short term and long term health (see section 2.4).

It is apparent that local ozone events in this area are strongly associated with a south easterly wind direction (Stacey, 1994) of about speeds of 2-4 ms^{-1}. This feature is consistent for ozone levels in Bedford recorded in previous years where Bedford O_3 events occur with mild south easterly winds and sunny warm days (Sweeny 1992; Sweeny 1994). They also tie in with the association recognised in (Chung, 1977; McKendry, 1993) between ozone, wind speed, location and weather type.

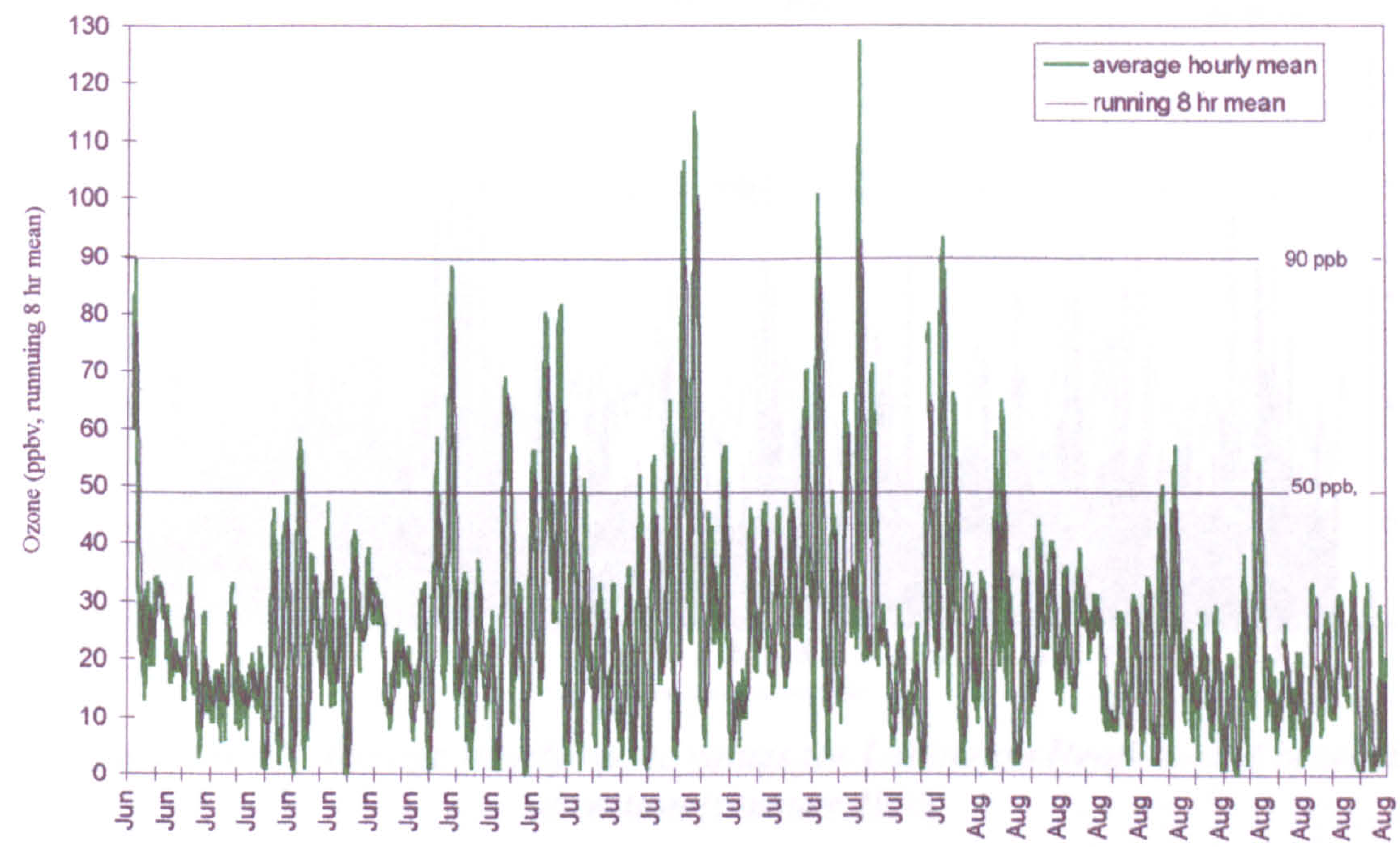


Figure 6-10 Ozone measurements using chemiluminescence for Bedford 1994

Another feature of the air pollution profile in Bedford, shown in Figure 6.11 (source Bedford Borough Council) is the notable levels of NO_2 in this area.

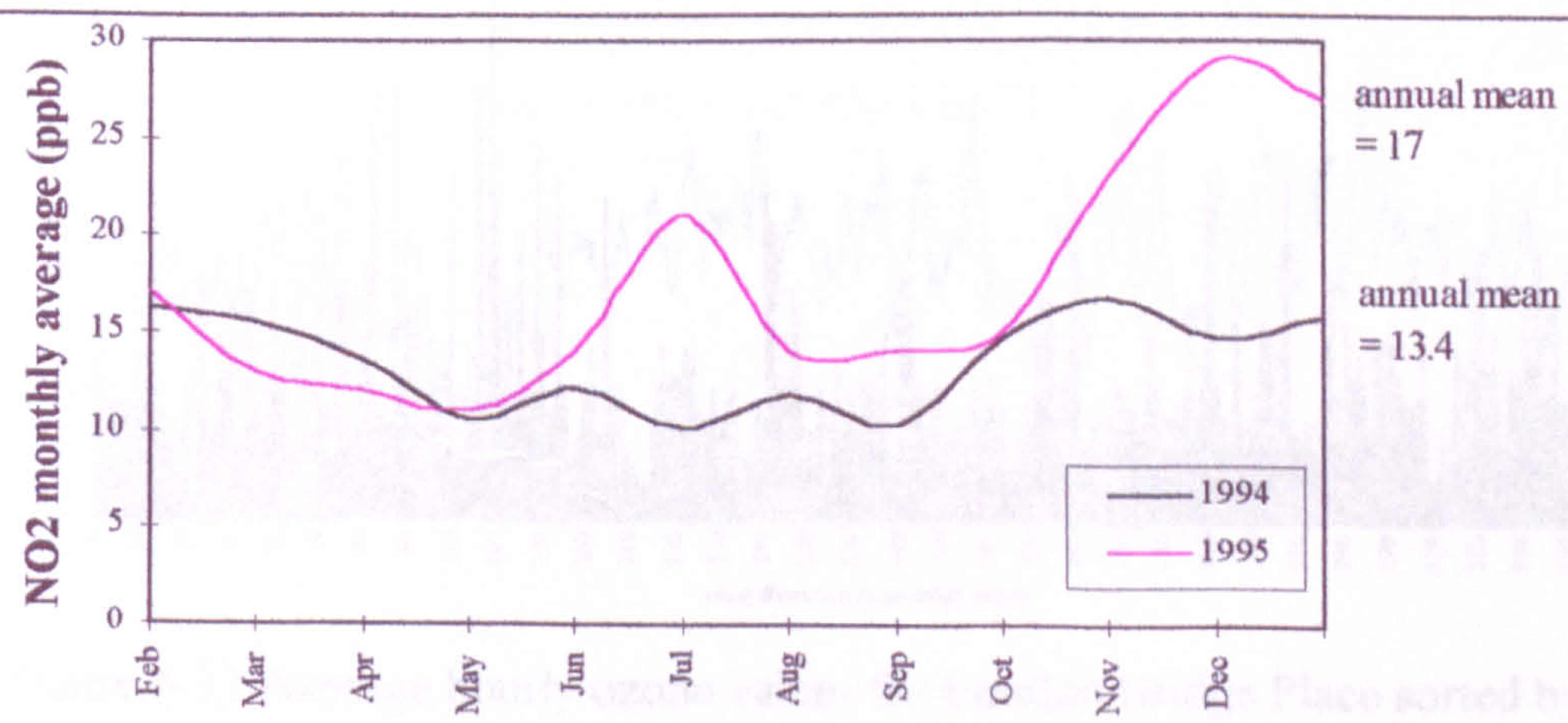


Figure 6-11: Monthly NO_2 levels for Bedford; 1994 and 1995

6.4.3.4 Comparison Ozone Events North and South of London

Figures 6.12 to 6.14 show hourly ozone concentration compared to wind direction and speed (hourly readings) to illustrate how tropospheric ozone varies (using hourly readings) to the NW and SE of London.

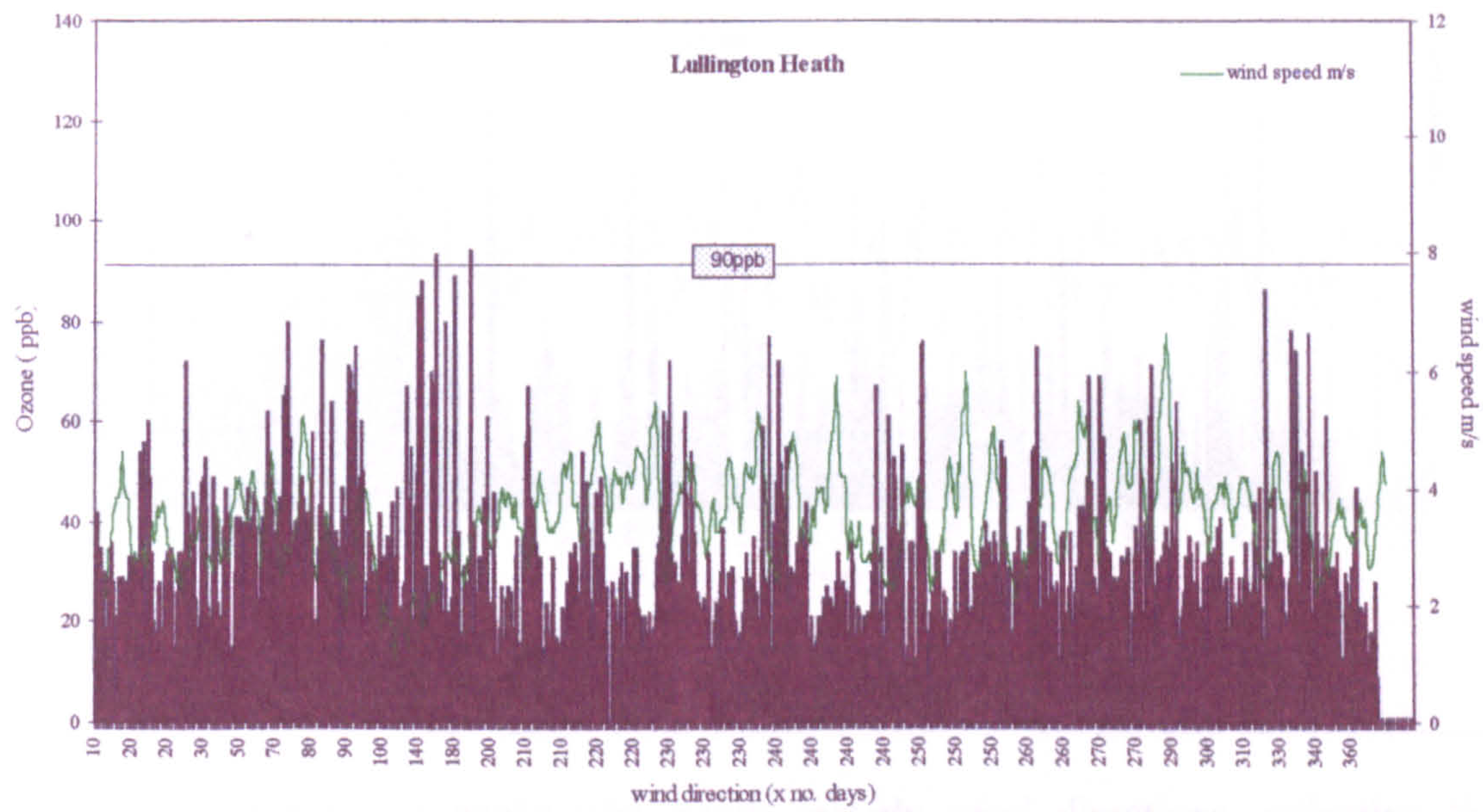


Figure 6-12: Average hourly ozone values for Lullington Heath sorted by wind direction (summer 1993)

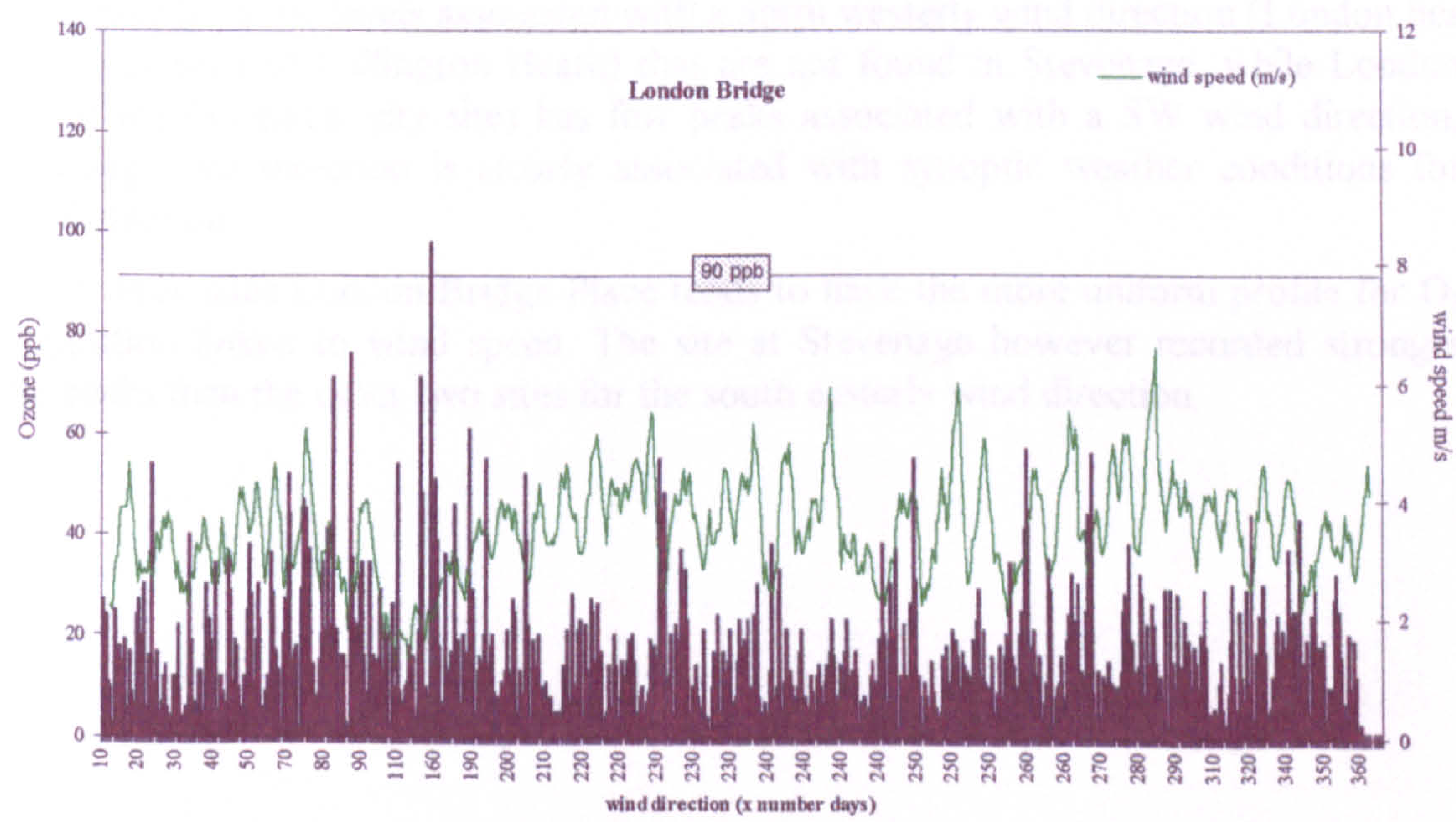


Figure 6-13 Average hourly ozone values for London Bridge Place sorted by wind direction (summer 1993)

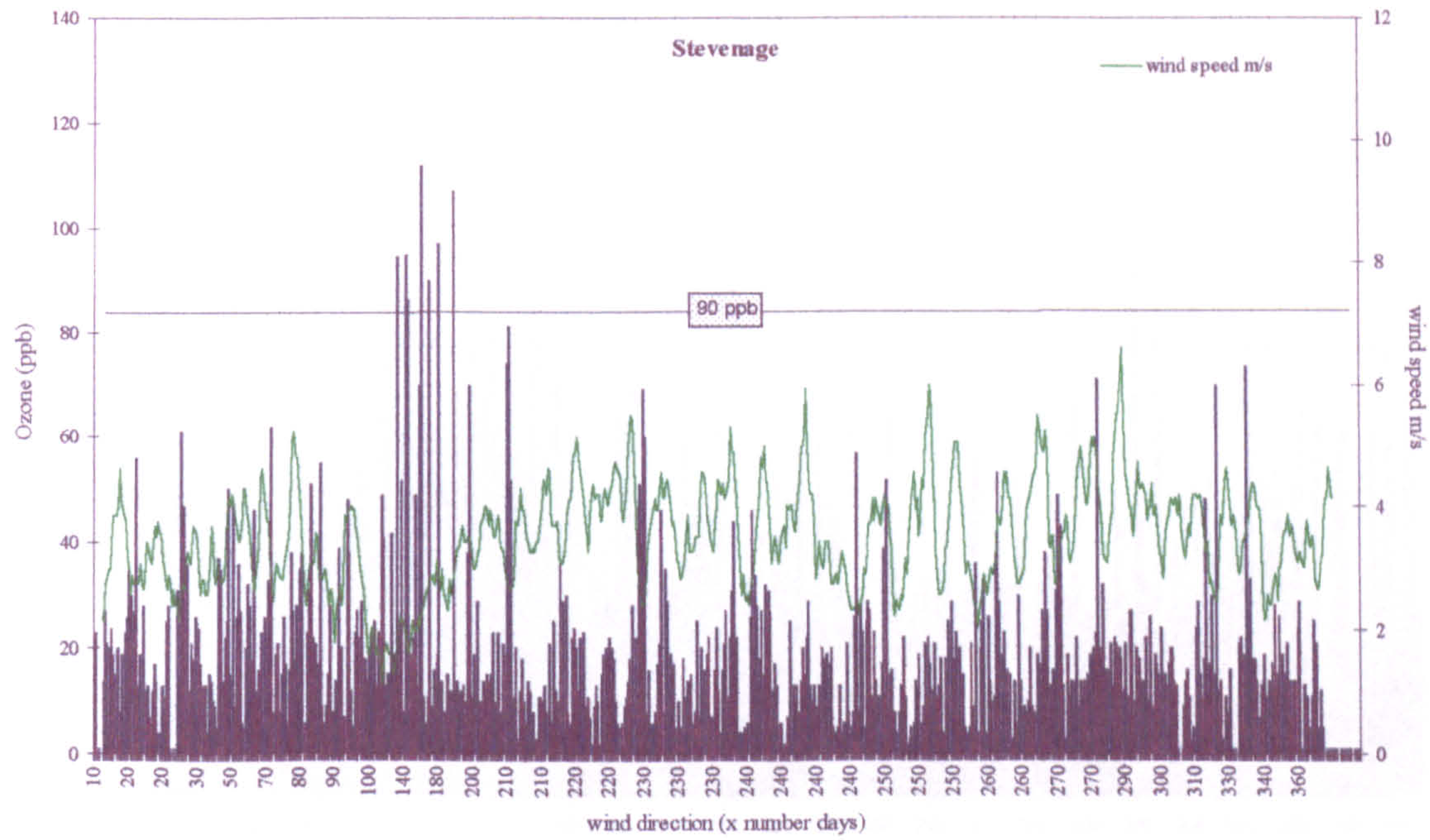


Figure 6-14 Average hourly ozone values for Stevenage sorted by wind direction (summer 1993).

While, all sites experience peaks with south easterly wind directions, reflecting the identified European scale ozone river (DoE, 1997), it is notable that these peaks are less for Lullington Heath than for Stevenage. Lullington Heath however, does have mild peaks in hourly ozone levels associated with a north westerly wind direction (London lies to the north west of Lullington Heath) that are not found in Stevenage, while London Bridge Place (a central city site) has few peaks associated with a SW wind direction, even though this direction is closely associated with synoptic weather conditions for ozone formation.

Of these three sites London Bridge Place tends to have the more uniform profile for O_3 concentration linked to wind speed. The site at Stevenage however recorded stronger ozone peaks than the other two sites for the south easterly wind direction.

Figures 6.15 to 6.17 show average hourly ozone readings for Lullington Heath, London Bridge Place and Bedford for 1994, sorted by wind direction.

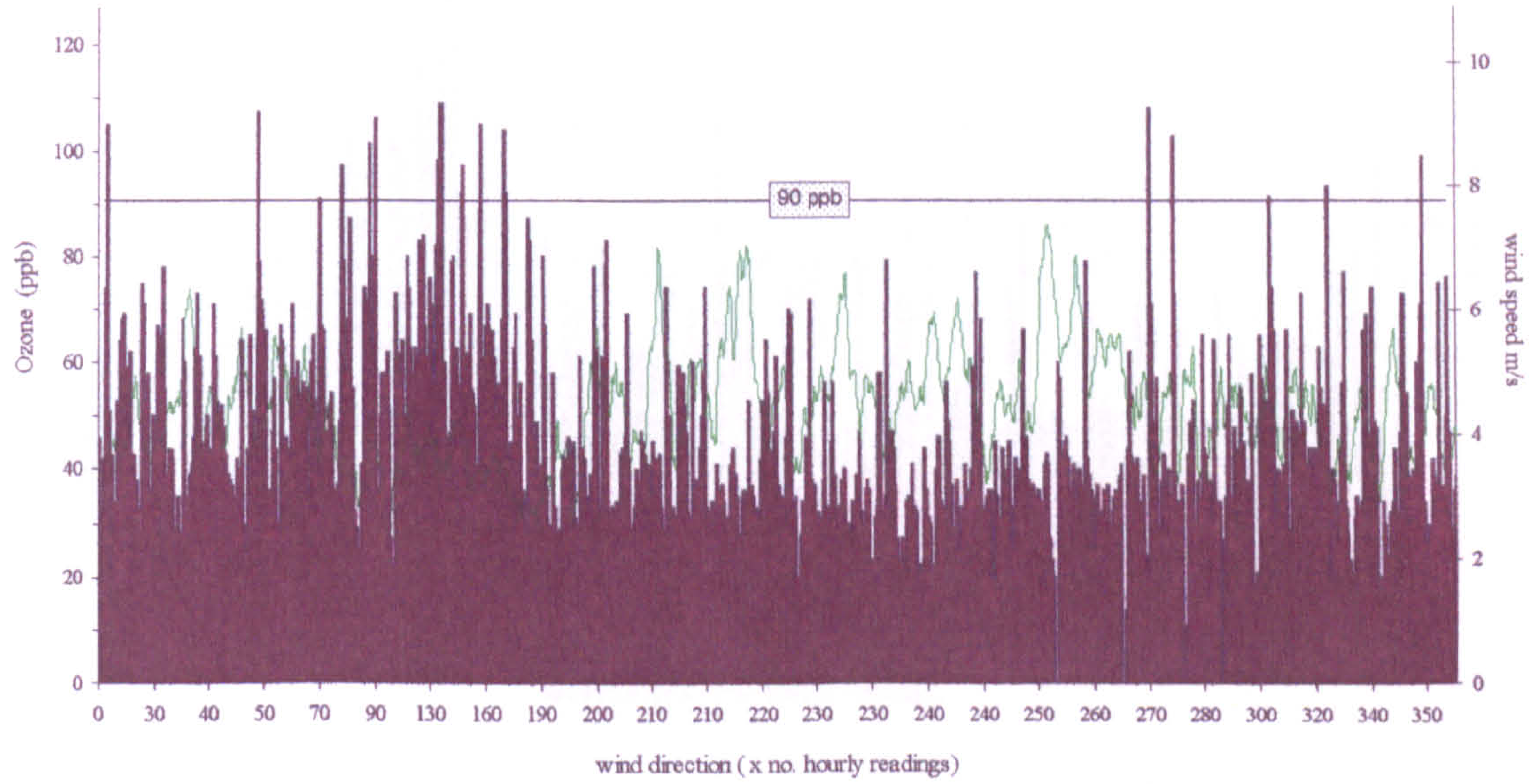


Figure 6-15 Average hourly ozone values for Lullington Heath sorted by wind direction (summer 1994)

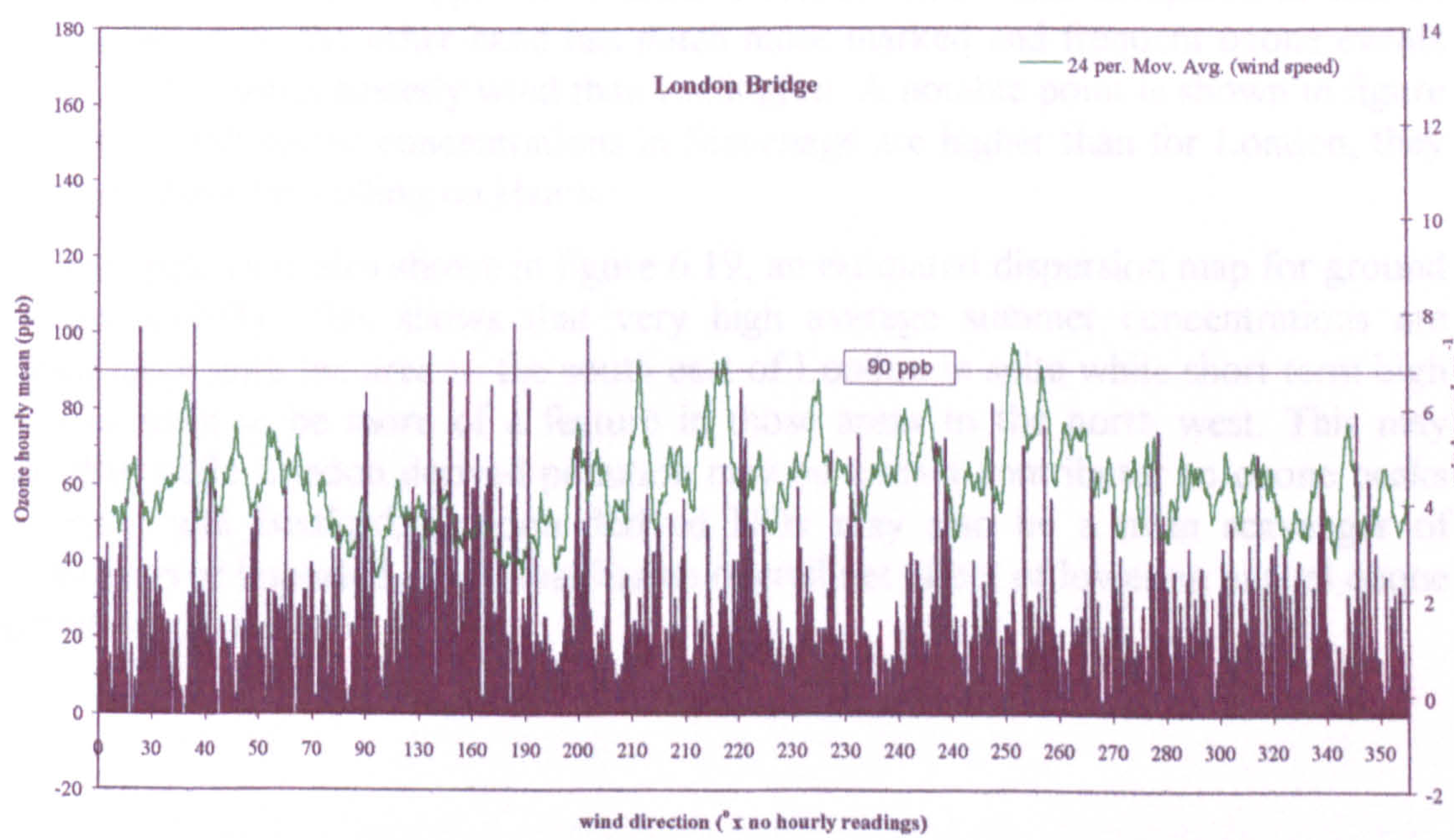


Figure 6-16 Average hourly ozone values for London Bridge Place sorted by wind direction (summer 1994)

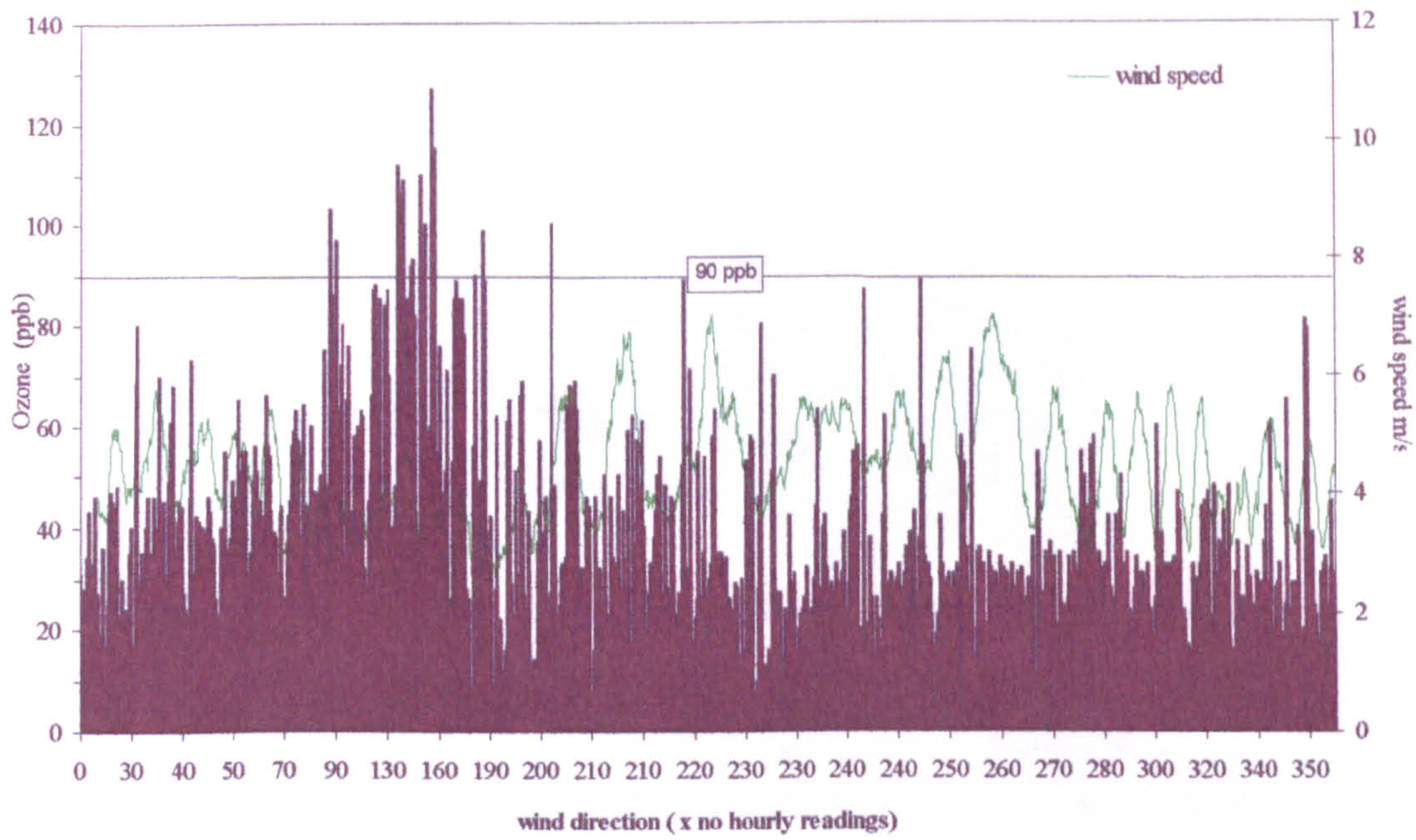


Figure 6-17: Average hourly ozone values for Bedford sorted by wind direction

One can see that there is a similar pattern here to that seen in the previous figures, but even more marked. While all figures show distinct peaks associated with the synoptic wind conditions, Lullington Heath also has distinct peaks of ozone concentration into the poor band of air quality (90 ppb) for a north westerly wind when compared to that of Bedford. Bedford on the other hand has much more marked and frequent ozone events associated with a south easterly wind than Lullington. A notable point is shown in figure 6.18: while overall ozone concentrations in Stevenage are higher than for London, they are less than those for Lullington Heath.

This general pattern is also shown in figure 6.19, an estimated dispersion map for ground level ozone (1993). This shows that very high average summer concentrations are associated more with the area to the south east of London in spite while short term high level peaks seem to be more of a feature in those areas to the north west. This may indicate that while London derived pollution may be a main contributor to ozone peaks in Stevenage and Bedford, London derived NOx may also be a main scavenger of European derived imported ozone that has an overall net effect of lowering annual ozone concentrations to the NW.

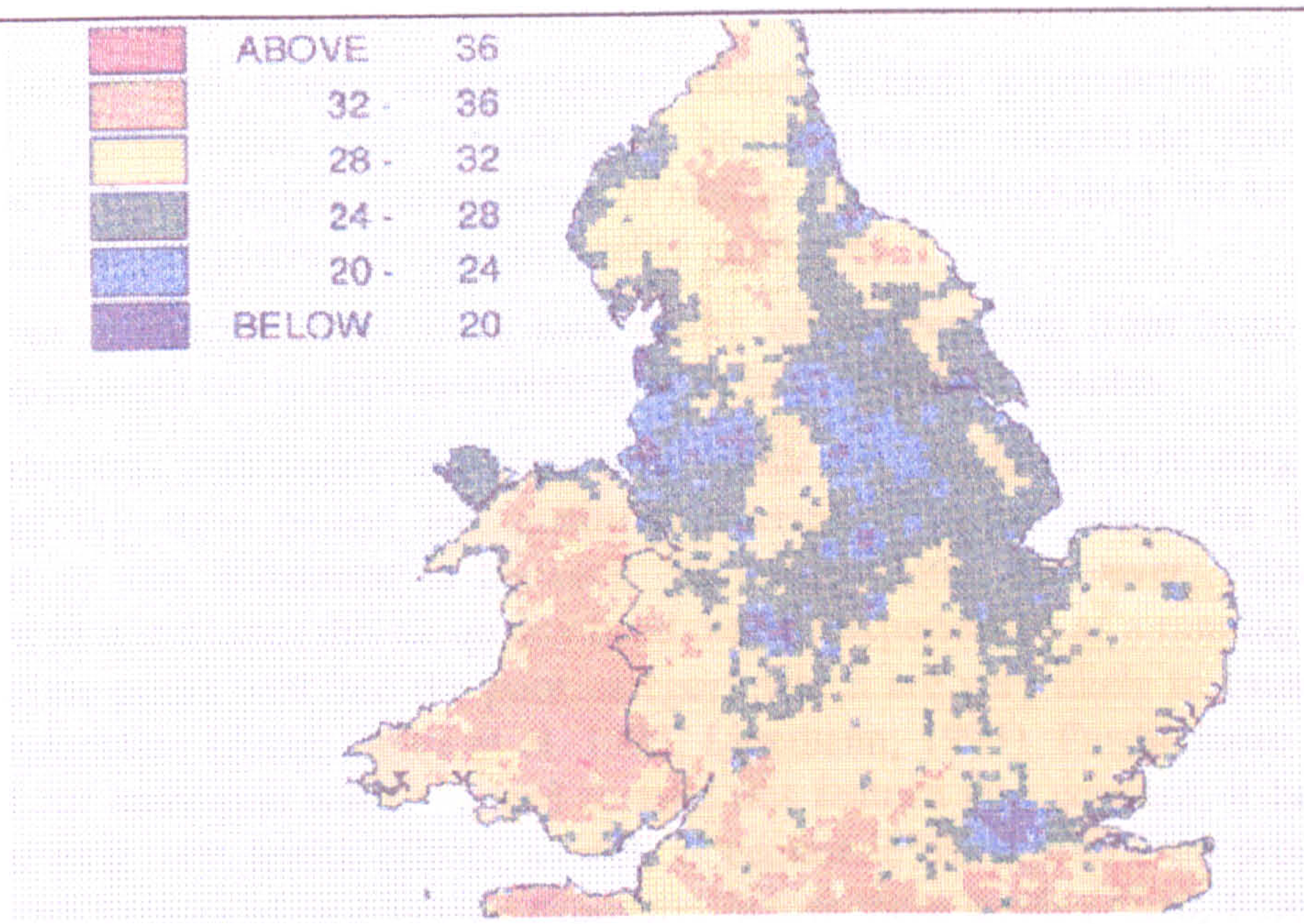


Figure 6-18: Region Dispersion Map for Ozone 1996 (after DoE, (1997) http://www.environment-agency.gov.uk/s-enviro/states/3-3.html)

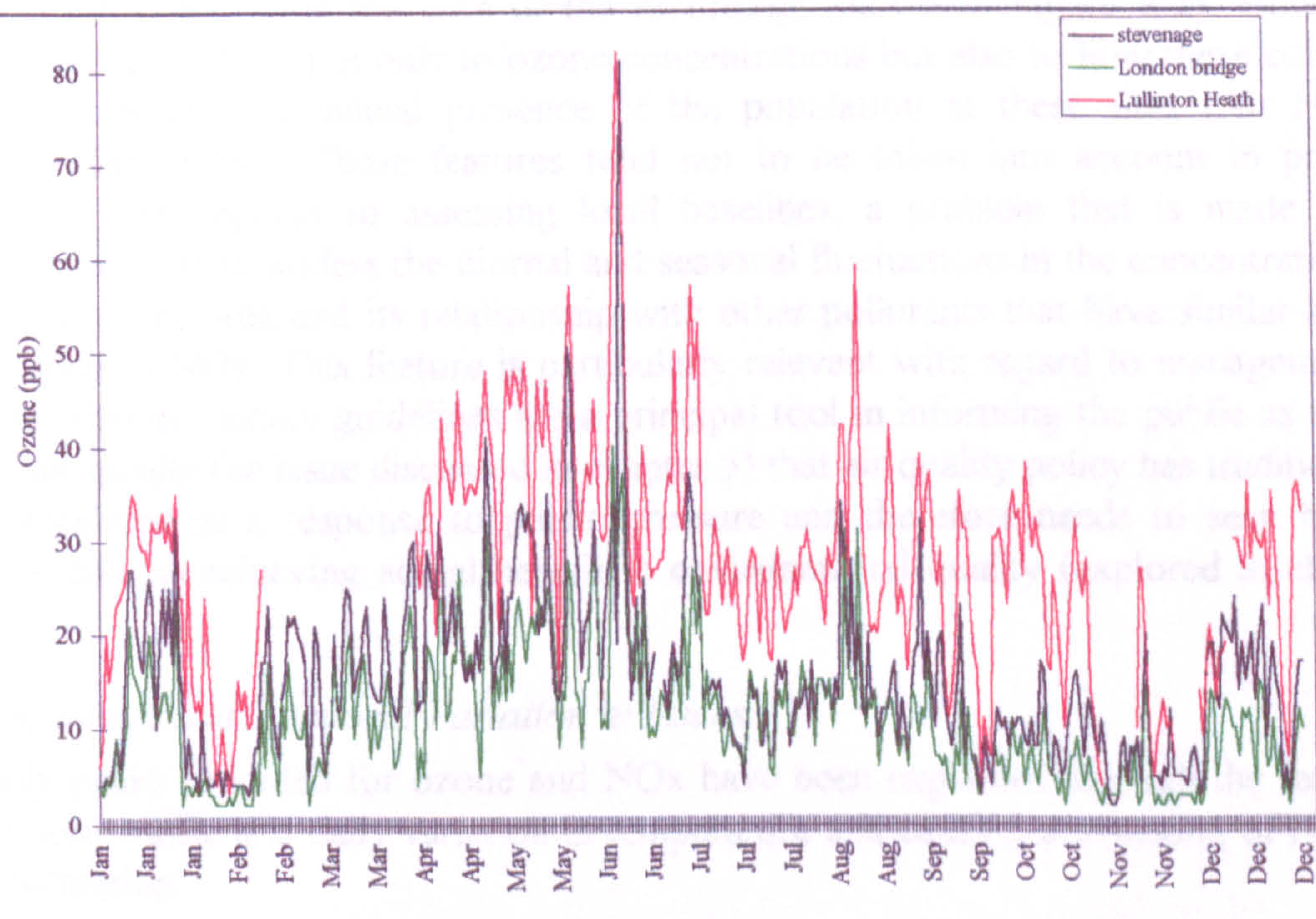


Figure 6-19 A comparison of daily ozone levels between Stevenage, London and Lullington Heath for 1993

6.5 Discussion and Conclusions. Tropospheric Ozone in Bedford: A case of many issues

Bedford's summer-time ozone concentrations clearly breach government guidelines (Figure, 6.2). Furthermore, this breach may be of greater magnitude than often communicated if one considers the relevance of measurement methodology for air quality standards from the perspective of local air quality guidelines.

As pointed out in chapter three, short term health effects resulting from tropospheric ozone may be brought on by exposure periods of as little as fifteen minutes.

Air quality standards with regard to tropospheric ozone are calculated on running 8 hour means. Using this time period air quality is classed as good when the ambient concentration of this substance is between 50 and 90 ppb. However, Figure 6.1 illustrates that in some cases this air quality band may be experienced as a running 8 hour mean with ozone peaks well into the poor category which are very likely to cause short term lung dysfunction (Allen, Foley et al, 1993; Lippmann, 1993). Furthermore even if measurement for standards were changed to take this feature into account, it has been indicated that long term health effects, as well as economic damage to crop production may, occur with prolonged or repeated exposures below these levels (Allen, Foley et al, 1993; Walters, 1994). Therefore even if the number of episodes of ozone concentration exceeded information or warning thresholds (described in chapter 5) were reduced the local population may still suffer long-term or economic effects (Figure 6.1).

In addition it should be noted that ambient concentrations are often measured out using fixed-site monitors (as is the case of the recordings shown in Figure 6.2). However, health effects are linked not only to ozone concentrations but also to how these coincide with the activities and indeed presence of the population at these sites (Air Health Strategy, May, 1996). These features tend not to be taken into account in present monitoring with regards to assessing local baselines, a problem that is made more complex when one considers the diurnal and seasonal fluctuations in the concentration of ozone in any one area and its relationship with other pollutants that have similar health effects, such as NOx. This feature is particularly relevant with regard to management if one notes that air quality guidelines are a principal tool in informing the public as to the state of air quality (an issue discussed in chapter 5) that air quality policy has traditionally been formulated as a response to public pressure and therefore needs to seen by the general public as achieving actual benefit in environmental quality (explored in chapter 4.3).

6.5.1 Seasonal and Temporal Variation in Issues

The daily peaks recorded for ozone and NOx have been explained through the features of rush hour traffic and daily variation in temperature and causing scavenging of NOx in ozone formation.

Figures 6.3 and 6.4 show troughs in NOx related to both ozone scavenging and NOx dispersion (McKendry, 1993; Chameides, 1994). The first peak in ozone is due to increased ultra-violet sunlight encouraging ozone production from the early morning and imported sources of NOx. The second peak in O_3 has been attributed to wind dispersion of NOx (resulting in less scavenging) and by suppression of the boundary layer allowing downward migration of stratospheric ozone (Chameides 1993; Chung 1977).

An interesting feature of these two graphs is that although both locations show the same patterns in the inverse relationship in these peaks, there is also an inverse relationship between the two locations in the magnitude of the peaks. The peak NOx values are higher in London for the same time period as those in Stevenage. This may indicate that while both while both pollutants are present and interacting at these sites, ozone concentrations are higher in Stevenage and may be a reflection the flow of precursors (Chameides, 1993) from London (a high density city) to Stevenage (a smaller commuter town).

The temporal variation shown by these pollutants (Figures 6.5 and 6.6) has been put down to the increase in ozone productive synoptic weather conditions apparent in the summer months (i.e. increased solar intensity and lower winds (Hiedorn and Yap 1986) causing scavenging of local NOx by imported O_3 (see chapter 3.2). This argument is supported if one considers the difference between the two sites. In London where NOx concentrations tend to be relatively high compared to ozone (see section 6.4.3), the trend for NOx is much more pronounced.

While summer levels of NO_2 are much higher in London compared to Stevenage, NOx levels are similar to those in Stevenage. This feature, similar to that found around Ontario has been put down to scavenging of NO in ozone formation (Hiedorn and Yap, 1986). Ozone levels in this locality tend to be lower than Stevenage, suggesting upwind transport of the resultant tropospheric ozone. The argument is supported when one considers the very high NOx concentrations at times of the year when the synoptic climatic conditions are not present.

This raises problems for the management of air quality with respect to a particular pollutant with respect to the perception of air quality issues. The implications are that while air pollution is often termed generically in local air quality bulletins (described in chapter 5.4) it can be seen that in Bedford an issue surrounds elevated ozone levels in summer months and NOx in winter (Figures 6.10 and 6.11).

However, while management plans designed to combat O_3 may be relevant for this pollutant in the summer months in Bedford, they may not be relevant at other times of the years where NO_x reduction is of more pressing importance. This is relevant since the UK National Air Quality Strategy lays out standards for NO_2 of 21 ppb annual mean (DoE, 1997) and it can be seen (Figure 6.11) that Bedford comes close to this standard. Indeed its can be suggested that without the summer troughs in these values, probably due to high ozone values recorded in this period, the NO_2 levels would be much higher.

The feature is complicated by the fact that legal requirements under the 1995 Act do not state that LA's need to meet ozone standards. Therefore the need to reduce any pollutant in this area of the district council may well be for NOx, rather than the more health threatening levels of ozone. Often strategies aimed at the two substances are not compatible (a point noted in chapter 3 and discussed in more detail in chapter 8).

The situation is complicated when one takes into account the regional nature of this pollutant one by a range of other conflicting issues surrounding the management of the pollutant, not least that this area is overall designated as a NMVOC management area in terms of ground level ozone (Figures 6.7 and 6.8, DoE 1997). However, the prevailing pollution issue in one of the identified sources of precursors to Bedford's ozone events, London, is a recognised management problem in terms of NO_2 pollution (note the daily peak shown in Figure 6.3 of over 110 ppb, well above the 104 ppb for 1hr peaks, the guideline set out in the UK National Air Quality Strategy). Additionally it has been suggested that reducing NOx concentrations in London might lead to an increase in ozone concentrations in this area (Nuttall, 1995) which is already a problem pollutant, but less so in magnitude than NO_2. This situation is complicated if one considers some of the possible implications of larger scale ozone/precursor relationships.

6.5.2 A Multi-Scale Ozone River?

The fact that the source of ozone pollution is usually distant from its impact is well documented (Sweeny, 1994; Chameides, 1993; Chameides, 1994; Chung, 1977; PORG, 1993; McKendry, 1993; Kankidou, 1993; Wolf, 1980; Commission for the European Community, 1994). It was on this basis combined with the opinion that :

> *"Action taken unilaterally in the UK is likely to have a significant influence on extreme peak concentrations in the UK, Ozone episodes would still occur if UK emissions were eliminated, albeit with a reduced spatial coverage and severity, due to long range transport. Elimination of ozone is unlikely to change exceedences of the EPAQS recommended level to any significant effect but is likely to reduce EC ozone directive information threshold" and :*
>
> *"Whatever measure of ozone is taken, precursor sources in the rest of Europe appear to be at least twice as important as those within the UK"*
>
> (DoE, 1996)

that the government's air quality strategy excluded exceedences of this pollutant from their stated main tool for managing air quality into the next century, the local authority Air Quality Management Area (Air Health Strategy 1996).

Within the south central area of the UK one would expect raised concentrations of tropospheric ozone to be closely linked with a south easterly wind direction (DoE, 1997; Bower, Stevenson et al., 1994) since this is most closely associated with the synoptic conditions of high temperature, slight cloud cover, a low and heavily defined boundary layer, and moderate wind speeds (Wolf and Lioy, 1980; Hiedorn and Yap, 1986).

However, it should be noted that a feature of ozone rivers is a tendency for them to exist on different scales (a point identified in section 3.4). This multiscalar nature means that ozone rivers can range from large scale international flows responsible for general background levels and lower scale rivers at sub-national flows, to regional flows that are responsible for local peak levels (Kankidou and Crutzen, 1993; McKendry, 1993; Chameides, 1994). It is these small scale derived peaks that have been most closely linked with short term health effects on humans (Allen, Foley et al., 1993; Lippmann, 1993). However, long period exposure to low concentrations has been linked to long term lung damage and damage to crops (Elsom, 1996; Lippman, 1993).

Figures 6.9 through to 6.19 illustrated the regional air pollution profile in the South central region of the UK with reference to management issues arising from tropospheric ozone.

That London is a major source of NOx in this area is clearly shown in Figures 6.9 to 6.11, and the fact that these precursors are responsible for ozone formation away from this spot is supported by Figures 6.16 to 6.19. It is apparent that local ozone events in the area of Bedford are strongly associated with a south easterly wind direction (Stacey, 1994) at speeds of about 2-4 ms^{-1}.

When one considers that ozone is generated from its precursors over a period of about five hours, and that the main influences between source and reception of tropospheric ozone tend to be wind speed and direction (Chung, 1977; Chang and Rudy, 1993; Bower, Stevenson et al., 1994; Chameides, 1994), then one can estimate that the main source of precursor emissions linked to these peak ozone sites lies about 60 kilometres to the south west of this town, i.e. London and results from the conurbation's high road traffic density (Sweeny, 1994).

Figures 6.12-6.17 showed how the regional peaks and flows for tropospheric ozone relate to wind direction for a transect NW of London to the area SE of the city in order to illustrate the possible spatial distribution of ozone events to the North and South of London. The raised levels of ozone associated with south easterly winds in Lullington Heath (south of London, Figures 6.12 and 6.15) suggests that a large scale ozone river originating south of London, viz. Europe, may be responsible for the generally raised levels of ozone in the south east corner of England. However peaks associated in this area due to a north-westerly wind are not found in Bedford or Stevenage (Figure 6.14 and 6.17). This indicates a source of precursors to the NW of this area that are not present for Stevenage or Bedford and therefore brings the attention back to London.

Therefore the peaks found in the area to the north-west of London do seem to be in part the result of precursors originating in this area. However when one considers the tendency of ozone and its precursors to form multi-tiered flows (chapter 3.2, Chamiedes 1994), it may be the case that these London produced precursors may not only produce raised ozone levels in the area around the conurbation but may also be responsible for scavenging ozone imported from Europe. The effect of this may be an overall reduction in ground level ozone concentrations to the north west (since it is this wind direction that is associated with these events). That this may be the case is supported by Figure 6.18 as, while overall background concentrations in Stevenage are higher than for London, they are less than those for Lullington Heath .

The situation is however complicated again when one considers that Bedford has much more marked and frequent ozone events associated with a south easterly wind than Lullington Heath (Figures 6.15 and 6.17) indicating that there is a stronger input of precursor to this location associated with this wind direction compared to Lullington Heath. This source of precursor can be identified as London where ozone events while still present are more evenly dispersed with regards to wind direction and less marked due to ozone scavenging by pollutants (see Figures 6.13 and 6.16).

Therefore there is great question over this simple cause and effect relationship between Bedford's ozone issue and precursor emissions in London. While peaks to the north and south of London are similar in intensity and frequency (Figure 6.18), the longer term background concentrations of ozone are higher to the south east of the City (Figures 6.12, and 6.15) and do appear to be the result of a larger scale ozone river originating in Europe (DoE 1997, QUARG 19943). The lower ozone levels in London than the surrounding area arises due to rapid scavenging of this pollutant by local NO, that this is as is indicated by the trends in NO, NOx and Ozone in this area where high concentrations of NO are depleted in the summer by the presence of ozone in the reaction.

$NO + O_3 \rightarrow NO_2 + O_2$ (see chapter 3.1)

The net effect of these two processes on the area to the north of London is unclear and it may well be that while there is clear indication that London derived NOx and VOCs are responsible for localised short term peaks in Bedford, the scavenging of imported ozone by these same precursors may result in an overall reduction in background levels for the area to the north west.

6.6 Conclusions

The concerns over the impacts of air pollution on human health is an area are surrounded by uncertainty and incomplete scientific knowledge. It is however, generally accepted that the most damaging short term effects from ozone result from exposure to very short term peaks in concentration linked with the exercise and health regimes of the recipient (a point covered in chapter 3.4). Long term damage to human health and impacts on crops are on the other hand associated with lower concentrations over long time periods. The multi-scalar temporal and spatial patterns that typify ozone therefore make the management of this substance an extremely complex issue involving different issues at different locations.

The first issue raised in this chapter is the problem of monitoring. The main influence on monitoring approaches are at present duties under the 1995 Environment Act and cost (DoE 1997). This chapter has however illustrated that monitoring methodologies employed may be misleading the public on three counts. These are:

- Using the running 8 hr mean as a unit of measurement in Bedford may neglect a number of repeated 15 minute peaks.
- Monitoring programmes are carried out from fixed sites. They do not readily take into account the correlation between population dispersal patterns with high concentration short term peaks with exposure.
- Monitoring tends to be separated on a single pollutant basis. This neglects the overall pollution profile by failing to recognise the interdependence between NOx and ozone, concentrations of which are dependent on each other and both have recognised health effects.

In addition to these problems there are also issues related to the strong diurnal and seasonal fluctuations in the concentration of this substance. These are:

- Periods of prolonged exposure tend to exist over days. However the concentration of ozone over one day may vary markedly.
- Management plans aimed at combating ozone in Bedford need to recognise that this substance is only a problem in the summer months. During winter months management programmes need to be aimed at the most pertinent pollutant at that

time, viz. NOx. Management strategies for the two substances are not always compatible.

- It needs to be recognised that due to the relationship of NOx and ozone management strategies aimed at reducing one of these substances may result in increasing concentrations of the other. Both pollutants are identified problems (a point illustrated in chapter 5).

In addition to these concerns there are also problems within present legislation with regards to air quality management in that there is a strong emphasis on the local control of individual pollutants. With respect to Bedford's ozone problem this can be seen to have the following implictations:

- Bedford's ozone does not have a local source.
- Reducing motor transport emissions in Bedford may in fact worsen the Borough's ozone problem.
- The emission of precursors in London may be important in eliciting short term, high concentration peaks in tropospheric ozone, whereas European flows may be more responsible for the lower but longer term raised levels of the substance in this area.
- Management of precursors in London may reduce the number of peak episodes, but may also raise longer term background levels of ozone in Bedford due to reduced scavenging of European derived ozone.
- Management of precursors in London will have an effect on the population's activity patterns but may result in the replacement of high NOx levels in this area with high tropospheric ozone levels.

The implications for these findings for the local and regional management of ozone are pursued in chapter 8.

The next chapter will review the problem of tropospheric ozone from a different perspective. It looks at the cause of the pollutants, that of the use of the private motor car from the point of view of the values and needs attached to this activity in the area to the north west of London. The aim of the chapter is to illustrate the role that this behaviour serves with regards to the population in this area. It will show that, like the biophysical parameters, these needs and values show themselves as qualitatively and quantitatively different phenomena in different locations.

7. An Investigation into The Needs And Desires of the Car Driving Population

"The car has become an article of dress without which we feel uncertain, unclad and incomplete in the urban compound."

(McLuhan 1964)

"What Englishman will give his mind to politics as long as he can afford to keep a motor-car."

(George Bernard Shaw, The Apple Cart 1930)

While strategies aimed at managing air quality need to take account of the biophysical processes with which they are concerned, they need also recognise the nature of the social systems within which they work and are a part of, since the values and acceptance of individuals within society can affect the outcome and viability of any policy, programme or strategy that is introduced (this feature is discussed in depth in chapter 2). The previous chapter explored the nature of the physical system inherent to the issue of tropospheric ozone and illustrated how this system shows qualitative and quantitative variation across spatial and temporal parameters. In this chapter it is proposed that this is also the case with the social causes of the problem. It is argued that this feature needs recognition (North 1994; Ahuja, 1996).

Within the context of managing tropospheric ozone in the south central area of the UK, it can be seen that the behaviour responsible for the pollutant is the wide spread use of the motor-car (London Scientific Services and Committee 1990; Air Health Strategy December, 1996; DoE, 1996; DoE, 1997; Sweeny, 1992; Stacey, 1994). However the use of, the motor car, unlike many other activities causing air pollution, tends not to be an activity in itself but is derived from the general way in which society has organised itself (Chapter 3.6). Loss of personal access to private transport by either restricting its use or affordability may well result in the exclusion of people from a way of life that has evolved as an interaction between their own personal aims and desires and their social environment. Policy institutions aiming to manage transport must recognise the role that transport fulfils in terms of the individual drivers needs and desires. However fitting alternatives to suit every individual would be impractical. Therefore, one needs to look at how these desires show themselves as collective need within the social structure where management is aimed (Lemon and Naeem, 1990). Without this recognition it will be difficult to identify acceptable and applicable compensation for those affected by that policy (O'Riordan, 1996) and in the absence of such compensation the viability and outcome of the policy may be seriously compromised (Ahuja, 1996).

7.1 Aims

The aim of this part of the research is to identify the form of public utility derived from the use of the motor-car and the resolution of scale at which this feature shows variation. The research explored the qualitative nature of this utility in order to demonstrate that there is a major cultural incongruity between the values and perception of policy makers within air quality management and those who are the targets for policy. The findings of this research is used to support the argument for a cultural transformation in air quality management, from that of top down regulation or incentive to one of bottom-up/top-down mutual co-operation and conflict resolution.

To this end this chapter has the following aims:

- To review the make-up of the population sample with regards to how representative it is of the population as a whole
- To assess the needs and desires of the population in and to the north-west of London with regard to the use of the motor-car.
- To investigate the qualitative nature of these needs and desires
- To quantitatively assess and compare the strength of importance attached to these needs with regard to each other.
- To investigate the variation in the value attached to needs and desires with regard to the location and type of respondent.
- To review the problems that the findings pose for management and policy.

7.2 Method.

The research was carried out by means of on street interviewing and postal sampling using a brief questionnaire. The postal sampling was mainly used in the London area to reduce cost. The locations sampled were a mixture of different types of locality in terms of their population size in and to the north west of London.

7.2.1 The Survey Area

The area of study roughly coincides with that of the previous chapter. However, since the research only wished to demonstrate geographical variation rather than form an ethnographic study into car utility per se, it was possible to extend this area for more practical reasons (i.e. the location of associates who offered to collect data). The sites surveyed are listed below (see Figure 7.1)

Villages (Population Less Than 5,000)
Ampthill, Bluntisham, Brackley Carshalton, Clophill, Cranfield, Eversholt, Flitwick, Harlington, Leagrave, Lilley , Needingworth, Olney, Sharlstone, Silsoe, Stoke Poges.
Small Towns (5,000 To 50,000)
Corby, Kempston Hardwick, Huntingdon, Newport Pagnell, St. Albans, St. Ives, Warrington, Watford, Woburn Sands, Wolverton, Woodhurst, Wooton.
Large Towns/Small Cities 50,000 To 500,000
Bedford, Daventry, Kempston, Luton, Milton Keynes, Northhampton, Stevenage, Wellingborough
Large Cities (500,000 +)
London.

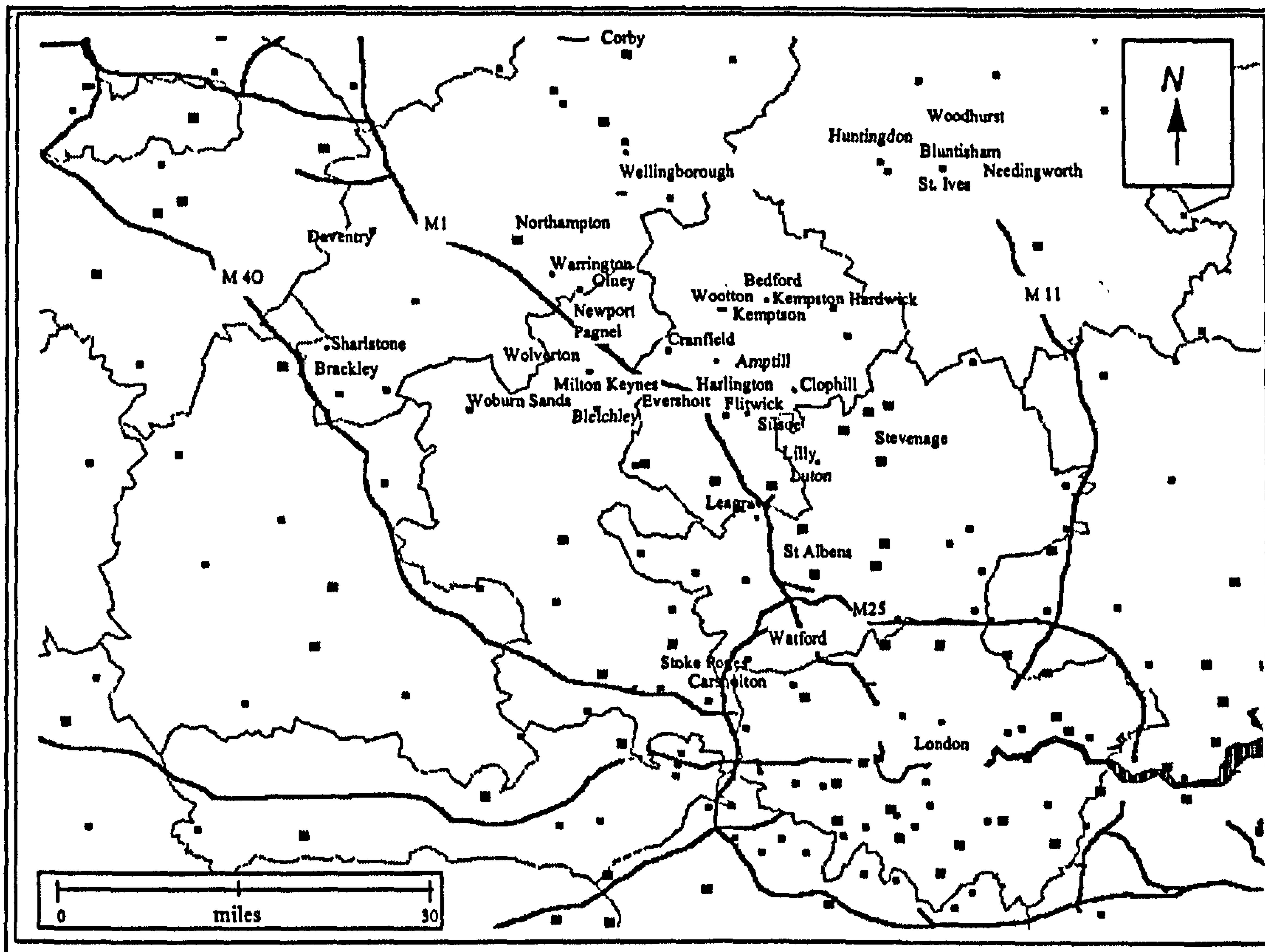


Figure 7.1: Survey Area and Locations

7.2.2 Questionnaire Design

The design process for the questionnaire is in Figure 7.2 and consisted of the following stages:

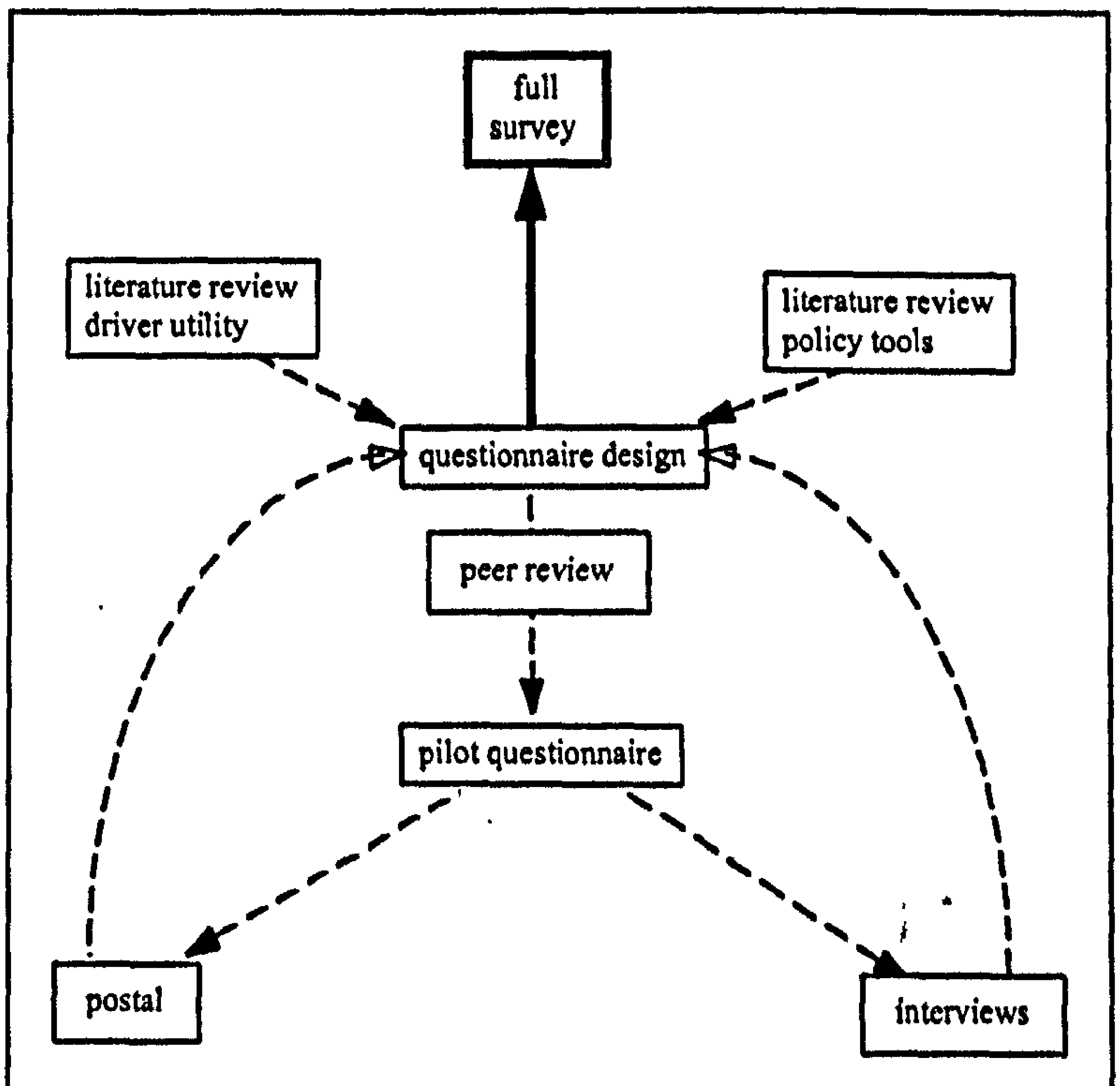


Figure 7.2: Schematic of the questionnaire design

A literature review was carried out into research aimed at identifying the aspects of well being people derive from the use and ownership of the private motor vehicle (Lowe, 1992; Brown, 1994) and an initial short list of these aspects was drawn up. The list was shown to a small sample of the car driving and owning population taken from colleagues of the author and members of the general public. Suggestions for other desires that the motor-car fulfilled were incorporated into a pilot questionnaire. This second draft list was then applied to a limited pilot survey.

The pilot survey invited comments on the wording of the questionnaire to test for clarity. The returned comments were incorporated into the questionnaire design. The final questionnaire (see appendix 4.1) incorporated the variables shown in section 7.2.3 and 7.2.4 and was extended to a full survey using the sampling method below.

7.2.3 The Dependent Variables

The questionnaire identified several key features linked to private transport and quality of life, which the respondents were asked to rate how important they thought these feratures where on a scale of 1 - 5, where 5 was the most important. The nature of these utility features are illustrated using quotes from respondents in appendix 4.4 and are as follows:

1. **Cost of transport**; the perceived advantage that private transport has over public in terms of economic outlay.
2. **Personal security**; this was intended to portray the sense of safety people gain from being able to use private transport. The pilot survey illustrated the various aspects to safety, these were; concern over walking on the streets after dark; worries over the threat to personal safety from other passengers on public transport; and the threat to personal safety from the motor-car when the respondent is a pedestrian or is riding a bicycle. The motor car was seen as the safe option (see appendix 4.4)
3. **Access,** the need or desire for transport to be easily accessible in terms of being available and close by when needed.
4. **Privacy,** desire to be away from strangers
5. **Comfort,** the importance of the travelling environment
6. **Flexibility** similar to access but concentrating on the advantage that private transport can have over public by running to the time table of the user rather than a large operator.
7. **Status** the perceived social standing obtained by ownership of private transport of varying expense.
8. **Being in control of the vehicle** the sense of well being from being your own driver.

It was recognised that the way the respondent personally defined these variables did show some degree of variation. The actual interpretation of the variables by the respondent was cross checked by the respondents being asked, before they has seen the list, "*do you prefer private to public transport, and if so why?*". These open responses were compared to the set responses.

7.2.4 Cultural Categories & Groups (independent variables).

The investigation aimed to test whether these independent variables would show variation across, spatial, temporal, occupational and gender parameters as has been postulated in chapter 2 (Hofstede, 1994). To this end respondents were asked to classify themselves within the following groups and categories:

- **Gender.**
- **Age group**: Each respondent was asked which of the following age group they belonged to.

1	17 - 25	4	46 - 55
2	26 - 35	5	65 +
3	36 - 45		

- **Economic grading;** was used to reflect how much money the respondent has available or is willing to make available for private transport. It was derived from a calculation on the car price based on its model and year and the *Parkers 1997 Car Price Guide*. The economic rating of the car owner was classed in the following groups:

1	>15,000	3	10, 000 - 6,000	5	3,000-1,000
2	15,000 - 10,000	4	6,000- 3,000	6	< 1,000

  This feature is aimed to reflect the amount of money respondents are willing or able to spend on private transport and does not necessarily correspond to their actual relative wealth.

- **Spatial;** two aspects of spatial variation were investigated, these were:
  1. **The type of area in which the respondent lived in terms of size** - divided into city (500,000+), big town (50,000 - 500,000), little town (5,000 - 50,000), and village (less than 5,000); and
  2. **the quality of alternatives to private transport in their area,** this was a measure of how the respondent rated their provision of local public transport themselves.

7.2.5 Sampling Method

The sampling method needed to achieve a wide coverage while gaining the necessary information from many respondents in order to allow for as significant a statistical analysis of cultural variables as possible. The approach used was a postal questionnaire for the more distant locations such as London and Luton, to save time and travelling expenses. Other sites were approached through on street interviews. On street interviews were carried out at random in major shopping areas (such as town and village centres and out of town precincts). The complete survey consisted of 240 interviews and 400 mailed questionnaires

Postal questionnaires were sent to random names selected from the telephone directory. There were two stages to the postal sampling. These were:

1. A mail shot of 47 pilot questionnaires in London and Luton (25 & 22 respectively) to test for return rates. The result was very high, a return of 23 (44%) was achieved. One can only assume that the motor-car is a subject people like to talk about albeit via a questionnaire; and
2. 400 questionnaires were posted, each envelope contained 2 questionnaires to account for multiple driver households. Of these 124 questionnaires were returned. This equalled a 33.5% return rate which was still high but lower than the pilot.

Recognised failings are, however, inherent to both techniques. While the postal survey did neglect non-telephone households, it should also be recognised that on street interview are selective in that they may well be bias to people who feel more open about talking to people.

7.2.6 The Analysis

The following analysis is divided into three main sections;

- **The Population Description**; to assess how representative this sample was of the wider car driving population. The cultural (independent) variables were also tested for association using a Pearson's correlation test (SPSS, 1995). These result were used to determine the statistical tests needed in the quantitative stage of the analysis of independent and dependent variables.
- **The Quantitative Analysis**

This consisted of two stages:

1. A test for association between the dependent variables.
2. Association of the strength of value placed on the aspects of utility was tested for using a comparison of means to identify possible association. The nature of any association was examined using a one-way ANOVA investigation (details of the statistical tools used are described in Frame 7.1).

The Qualitative Analysis; This section consisted of the an analysis of the responses to the question *"do you prefer public transport, if so why?"*. Each sentence was defined in terms of the independent variables identified in the quantitative analysis and any others that became apparent from the responses. Statements from the respondents were broken down to a series of key terms that represented the responses most closely. These key words were divided into two categories: What respondents use transport for; and why they use it.

Assignment was verified by the exercise of extracting the key words from each response each being carried out by five people. If a designation of a key word was repeated by three or more people it was recorded as applicable. The distribution and frequency of these responses was tested for, from the respondent population as a whole and for each of the cultural classifications using an array of graphical techniques.

Frame 7-1: A description of the statistical techniques

Mean comparisons were produced to test if an expressed factor of well being (dependent variable) is significantly linked to the independent variables such as age; gender; location; or economic grading of the respondent. The total score given by the respondent to each of the utility factors are grouped by independent variable and means are taken. A variation in means of these groups of over 5% from those shown by the total population will be considered as being possibly significant; variations below this are as not (SPSS Training Manual, 1996). However, variations of >3% and < 9% will qualify for further testing to allow for skewdness and deviation in the normalisation of the data. This testing was undertaken using a series of one-way ANOVAs.

The One Way Analysis of Variance (ANOVA) is a way of testing the *null hypothesis (Ho)* that several group means (μ_x) are equal in the population, by comparing the sample variance estimated from the group means to that estimated within the groups (SPSS, 1996). This can be expressed as follows:-

$$Ho\text{: } \mu_1 = \mu_2 = \mu_3$$

While based on the *t-test* the *ANOVA* test enables one to compare means from many groups. The assumptions of the ANOVA test are as follows:

- They are based on interval or ratio levels of measurement (i.e. not ordinal data),
- that the subjects are discrete and interdependent;
- they rely on homogeneity of variance; and normal sampling distribution, however it is noted that the test is resilient to slight skewdness (SPSS, 1996).

The variance of the samples tested refers to the extent to which individuals differ with respect to one of the expressed utility functions depending on the grouping of age, gender, residency, and economic grading. The logic of the test is that if the variance between the groups is significantly different from that within the groups i.e. that attributed to the classes of the independent variable), and the variance between (i.e. individual differences within each group, also termed residual variance).

ANOVAs are a more reliable tests than pure comparison of means since they are more tolerant to slight skewdness or interdependence, they are therefore used in the analysis where results from the comparison of means are not obvious or conclusive. Furthermore they allow the use of a post hoc test of significant variance that allows for an investigation of which groups differ from the others. The post hoc test used in this analysis is the least significant difference or LSD.

The ANOVA test therefore provides a useful and easily usable tool for illustrating variation between the sub-populations of our sample. It is a better and more convenient way to compare multiple means (Walsh 1996) than the standard *t test* on which it is based since for multiple groups there are fewer tests and thus less problem of overlap.

7.3 Results

The following set of results are shown in the order of a description of the population, the first then second stages of the quantitative analysis, and finally an analysis of the qualitative data. The two sets of data are discussed with relation to each other at the end of the chapter. Major implications of these findings for policy making are discussed in chapter 8.

7.3.1 Population Description

The following results explore the make-up of the entire population in terms of independent variable and possible relationships between the two. Any possible linkage between the dependents is tested using a *Pearson Correlation Analysis.*

7.3.1.1 Gender

The gender composition of the sample showed a slight over representation of males at 56% of all respondents. This reflects the higher number of males compared to females that form the UK driving population, which stands at 55% nationally (DoT 1996).

7.3.1.2 Age Group

Figure 7.3 shows the age make-up of the sample population. The largest single representation of age group was for 26-35 year olds, the age groups 17-26, 36-45, 45-55 are well represented. The first and last two age groups are represented by fewer respondents.

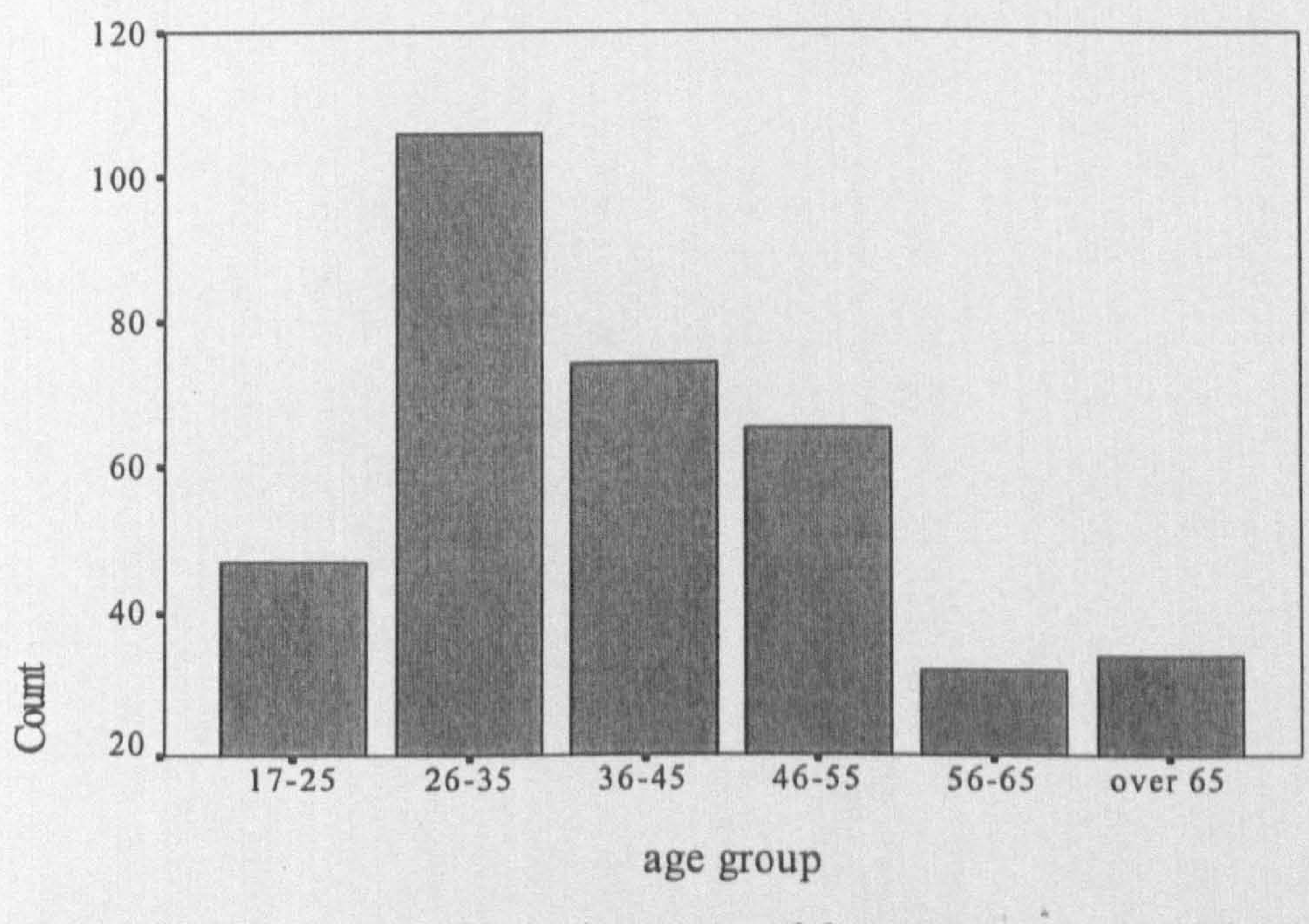


Figure 7.3: Age range of the sample.

In the case of the first age group (17-27) the low numbers of respondents may be due to under representation in the UK driving population since many people do not hold a driving license at this age. The low number of respondents in the latter age groups may well be due to the trend seen in the wider UK driving population as a whole(see Figure 7.4).

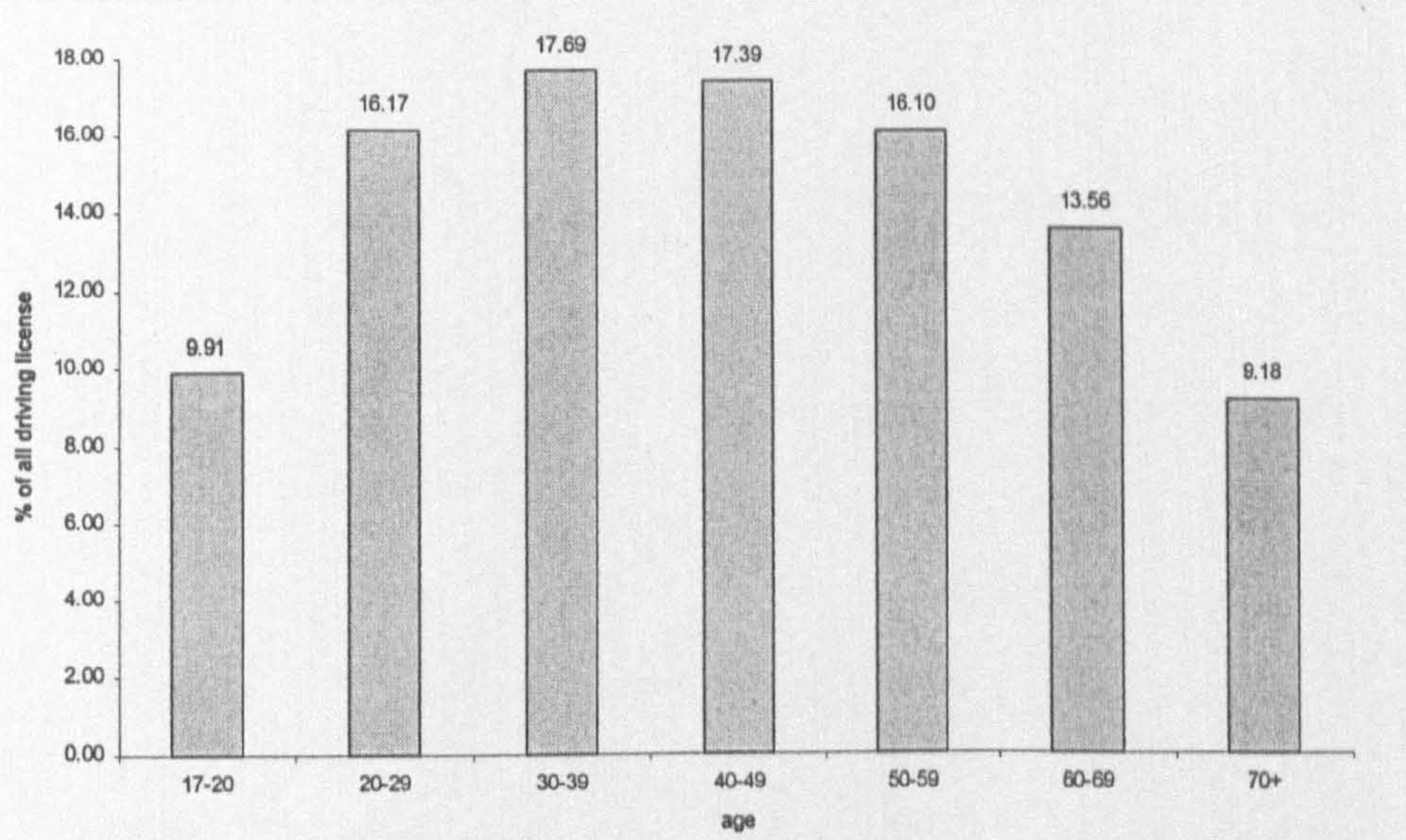


Figure 7.4: Age range of the whole driving public in the UK (after DoT, 1996)

7.3.1.3 Economic rating

The economic make-up of the sample is shown in Figure 7.5. The majority of the population belong to the £3 - 6,000 and under category. The wealthiest economic groups are represented by less than 10% of the sample. It should be noted however that this

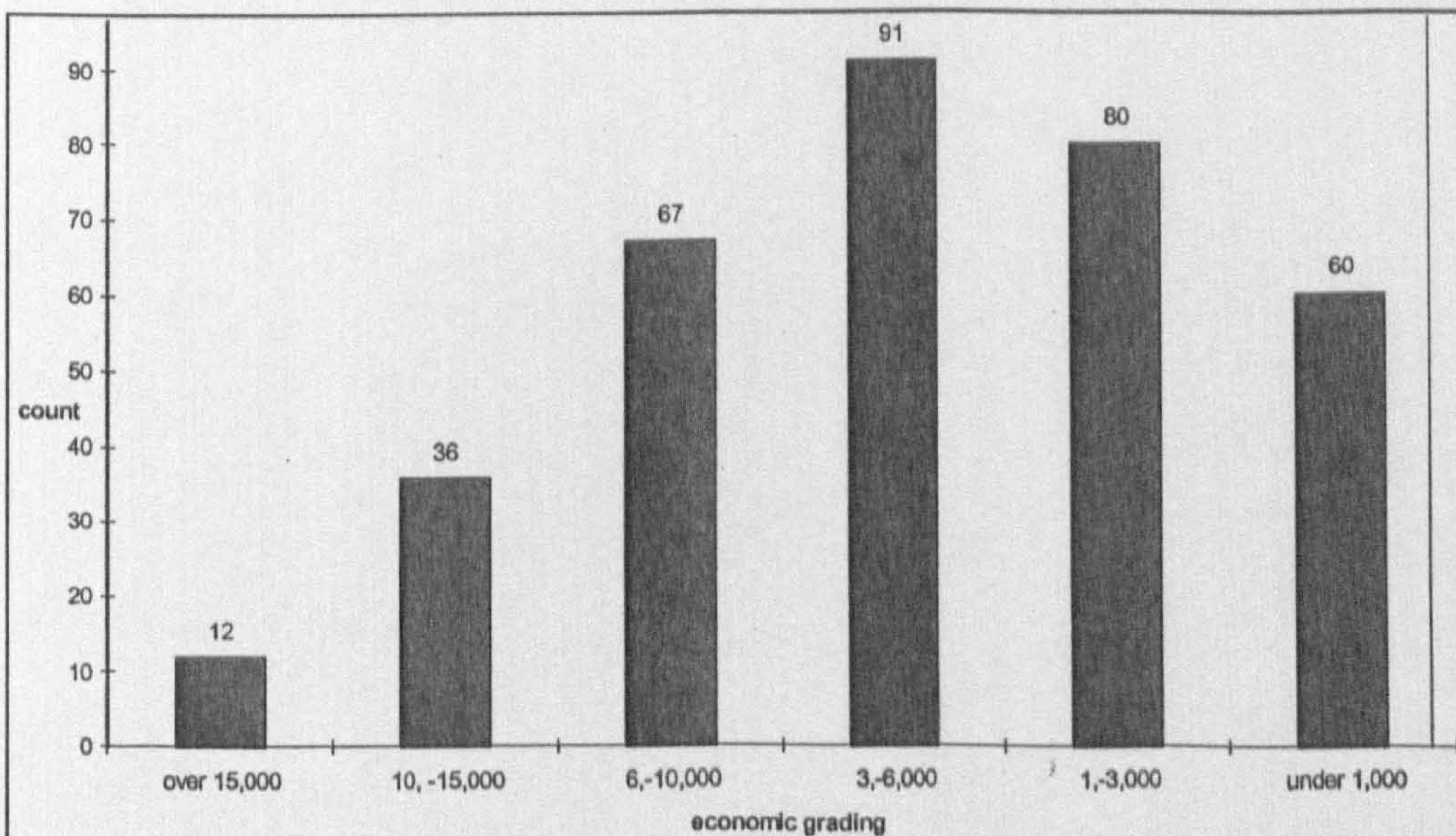


Figure 7.5 The economic grading of the sample

group does not directly correlate to actual wealth make-up of the population since this grading only represents the amount of money that the respondent is able or willing to dedicate to car ownership.

7.3.1.4 Size of Residential area

The size of the conurbation from which the respondent came was divided into the groups city, small city/large town, small town, and village (see 7.2.1). The two largest representations in the sample are from villages and small cities/large towns (Figure 7.6). This represents the study area which is centred on Bedfordshire, a county that contains Bedford but is essentially rural in nature but is in close proximity to Milton-Keynes, Northampton and Luton. The representation form a large city is the result of the sample taken from London.

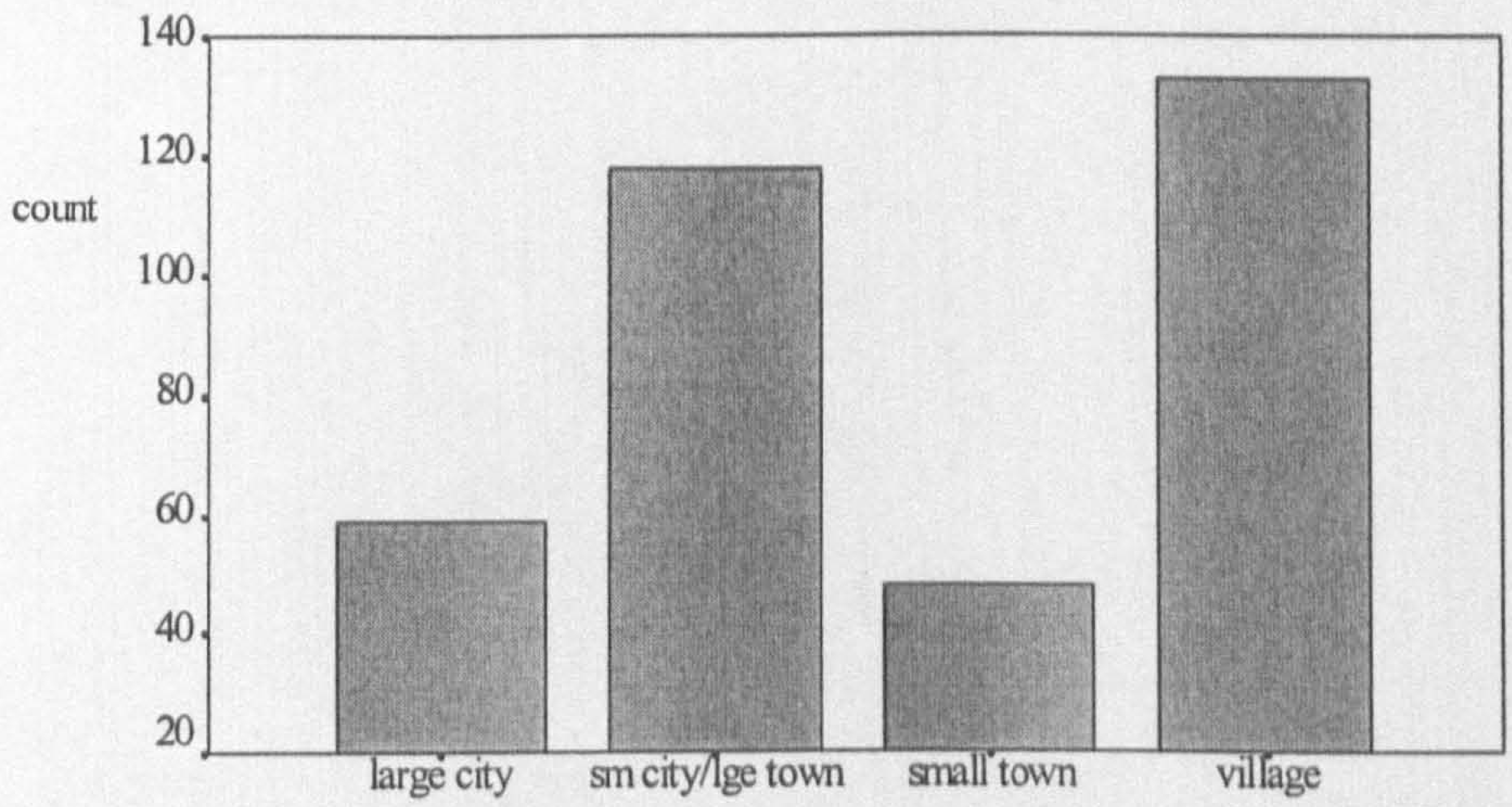


Figure 7.6: Size of respondents residential area as a count of the sample

7.3.1.5 Rating given to public transport.

This independent variable is slightly different from the others in that rather than a category of people it is a grouping of respondents in terms of how they consider transport in different localities (Figure 7.7).

The justification for using this approach lies in the fact that the research is interested in the perception of drivers as far as public transport provision is concerned since it is this perception that drives behaviour (see theoretical framework). Figure 7.7 shows that many people rate public transport as satisfactory or poor. The number of respondents who believe that public transport is good is very low, indeed as low as those respondents who don't know what public transport is actually like.

7.3.2 Associations Between Independent Variables.

This section will look at the strength of any association between the independent variables selected for the quantitative analysis in terms of their strength and the probability that they are due to more than chance.

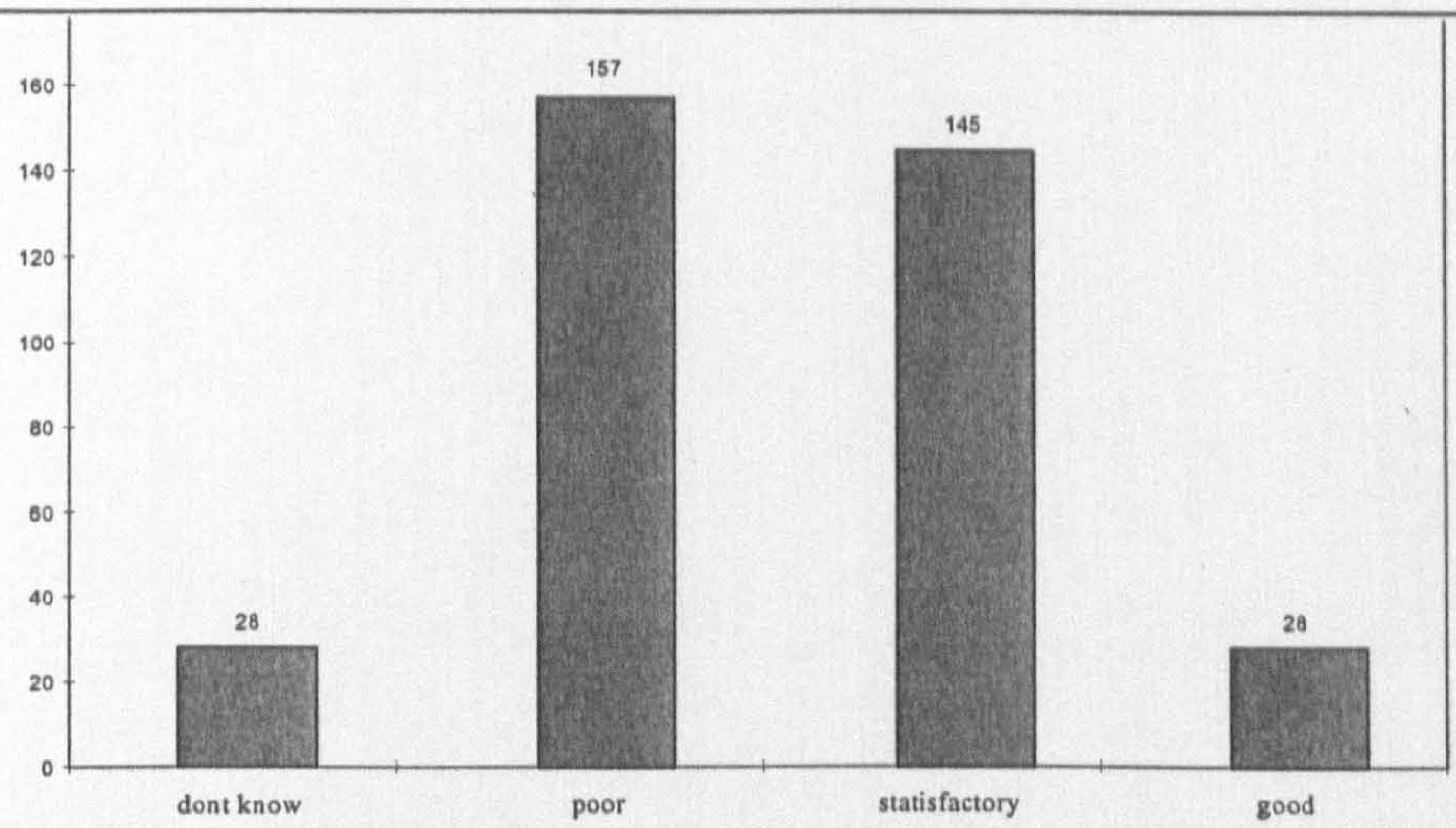


Figure 7.7: Rating given to local public transport by sample

The Pearson correlation test for association between the independent variables was carried out for all variables that are to be the subject of the ANOVA tests (Table 7-1). The aim of this is to establish any interference between independent variables in order to establish the need for multi-factor or single factor analysis of variance.

The Pearson correlation value is stated in the upper part of each cell. The absolute value (between 1 & 0) of this number indicates the strength of the correlation (either negative or positive) where 1 is strong. The probability of association (p value) is shown in the bottom of the cell and indicates the likelihood that the Pearson value arises from chance (null hypothesis) i.e. they are not associated. To convert this into a measure of association (i.e. likelihood of correlation) the value is converted to a percentage probability (%) using the equation 1-p multiplied by 100. Significant association (shaded) is strongly implied at the 99% confidence level and implied at the 95% (SPSS 1996).

Table 7-1: Correlation half matrix (for independent variables)

Independent Variables	gender	satisfaction with public transport	residential area	age group	econ grading	how long have you been driving
rate public transport	**.0390** *P= .232* % = 76.8					
residence type	**-.1474** *P= .003* *% = 99.7*	**-.1615** *P= .001* *% = 99.8*				
age group	**.0975** *P= .033* *% = 97.0*	**.0494** *P= .176* % = 82.4	**-.1631** *P= .001* *% =99.9*			
economic	**-.1111** *P= .020* *% = 80.0*	**-.0434** *P= .210* *% = 79.0*	**.0128** *P= .406* *% = 59.1*	**-.0664** *P= .109* *% = 89.1*		
how long driving	**.2088** *P= .000* *% = 100.0*	**.0279** *P= .300* *% = 70.0*	**-.1177** *P= .013* *% = 87.0*	**.8523** *P= .000* *%= 100.0*	**-.0695** *P= .099* *% = 90.1*	
how often do you drive	**.0353** *P= .506* % = 49.4	**-.0195** *P= .713* % = 28.7	**.2737** *P= .000* *% = 100.0*	**.0889** *P= .093* *% = 90.7*	**.0244** *P= .652* % = 34.8	**-.0558** *P= .295* % = 70.5

7.3.2.1 Gender

From table 7-1 it can be seen that the gender of the respondent is likely to be weakly associated with the other factors of *residential area, age group*, and *how long a respondent has been driving*. The probability that these are associated by more than chance is high (99%, 97% and 100% respectively). However, the weak strength of these correlations does not rule out the use of a single variant ANOVA analysis (SPSS, 1996).

Figure 7.8 shows the association between the make-up of the sample by age and gender. The main age group of respondents was the 26-35 year olds of which the sexual split was 50/50. While it can be seen that overall there was a equal split in the gender of the respondents for the three middle age groups, most of the 17-25 year old respondents were male. This weighting in favour of males also occurs with 56 -65 and over 65 year olds This association is supported in the Pearson's matrix where age group and gender are weakly correlated but at a 97% probability.

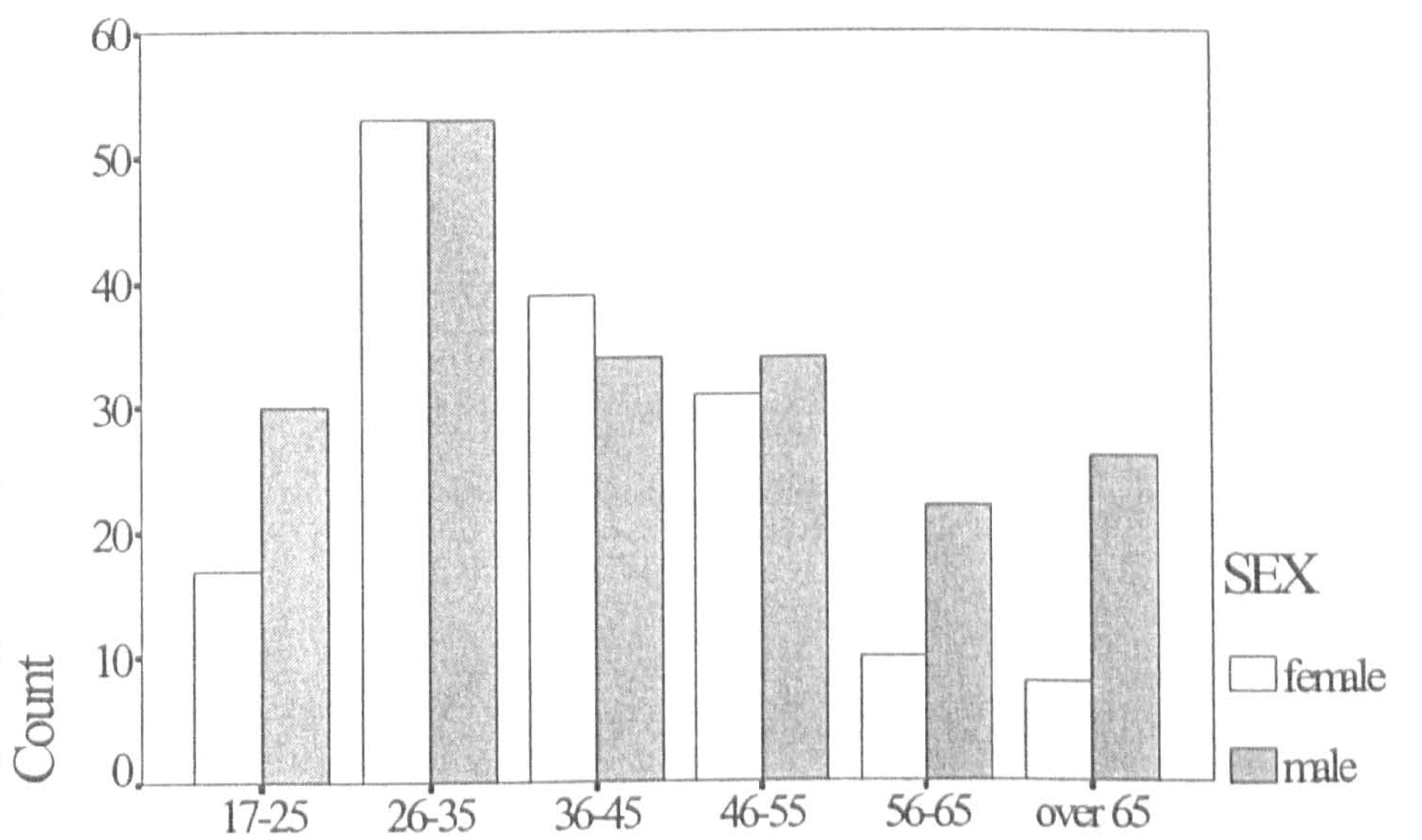


Figure 7.8 Gender of the population by age group

The reason for this relationship is indicated by the fact that the period of time that a respondent has been driving shows a stronger correlation than age (at a 100% probability). It is suggested the relationship between gender and age in the population is not a phenomenon of skewed sampling but a reflection of the difference in the age of gaining a license between the two sexes at the lower end of the scale (Evens, 1996) and the traditional under representation of women in the driving population as a whole (DoE, 1996) at the upper end of the age group.

Figure 7.9 shows the breakdown of the respondents in terms of residential area and their gender. In the largest conurbations the respondents were dominated by males, in the smaller the sexes were more equal in their representation. The domination of males in this section of the sample may be due to the fact that the big cities were sampled using postal surveys derived from random names taken from the telephone directory, and that males more often have the household telephone listed in their name than females.

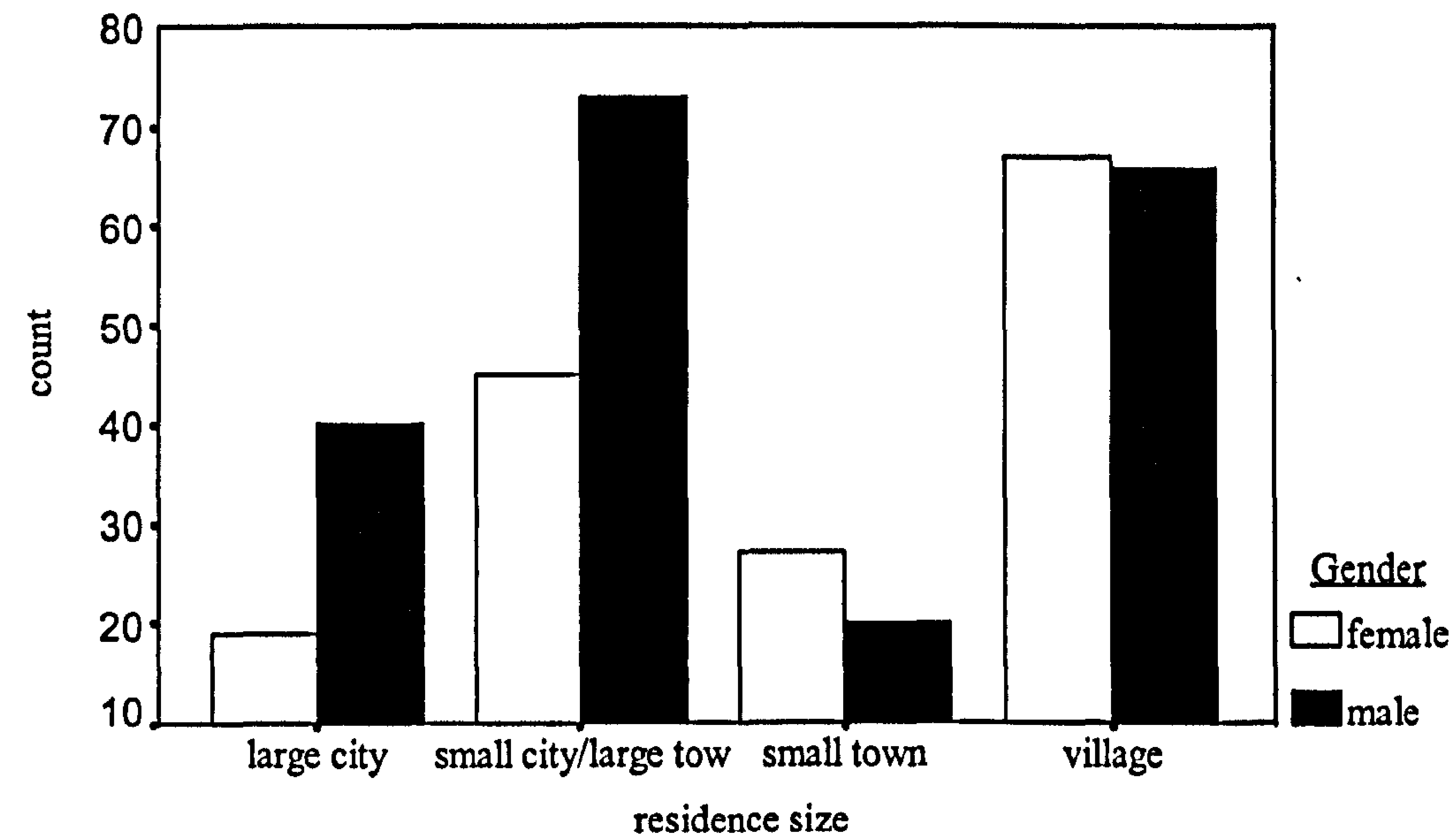


Figure 7.9: Breakdown of the respondents by residential area and gender

The low strength of the identified association, however, means that it is unlikely that any influence between these factors will significantly affect the analysis of the relationship between these variables and the dependents. However the relationship is borne in mind in the discussion.

There is no association between the gender of the respondent and how they rate public transport or how often they drive.

7.3.2.2 Size of Residential Area

The population size of the location in which the respondent lives shows weak association with *satisfaction with public transport, age group* and *how often do you drive* at the 99% + confidence level.. Associations are also indicated between this variable and how long a respondent has been driving at a slightly lower confidence level.

Figure 7.10 shows the age split of the respondents in terms of their residential area. The age range of the large town, small town and village appears to be dominated by the age groups 26-45, however the large city's respondents have a dominance in response from the age group 65+. This may be the result of the fact that the large city was surveyed using postal questionnaires and these may elicit a skewed response from this age group. However, the reason is not clear and may be due to high property prices in the centre of London.

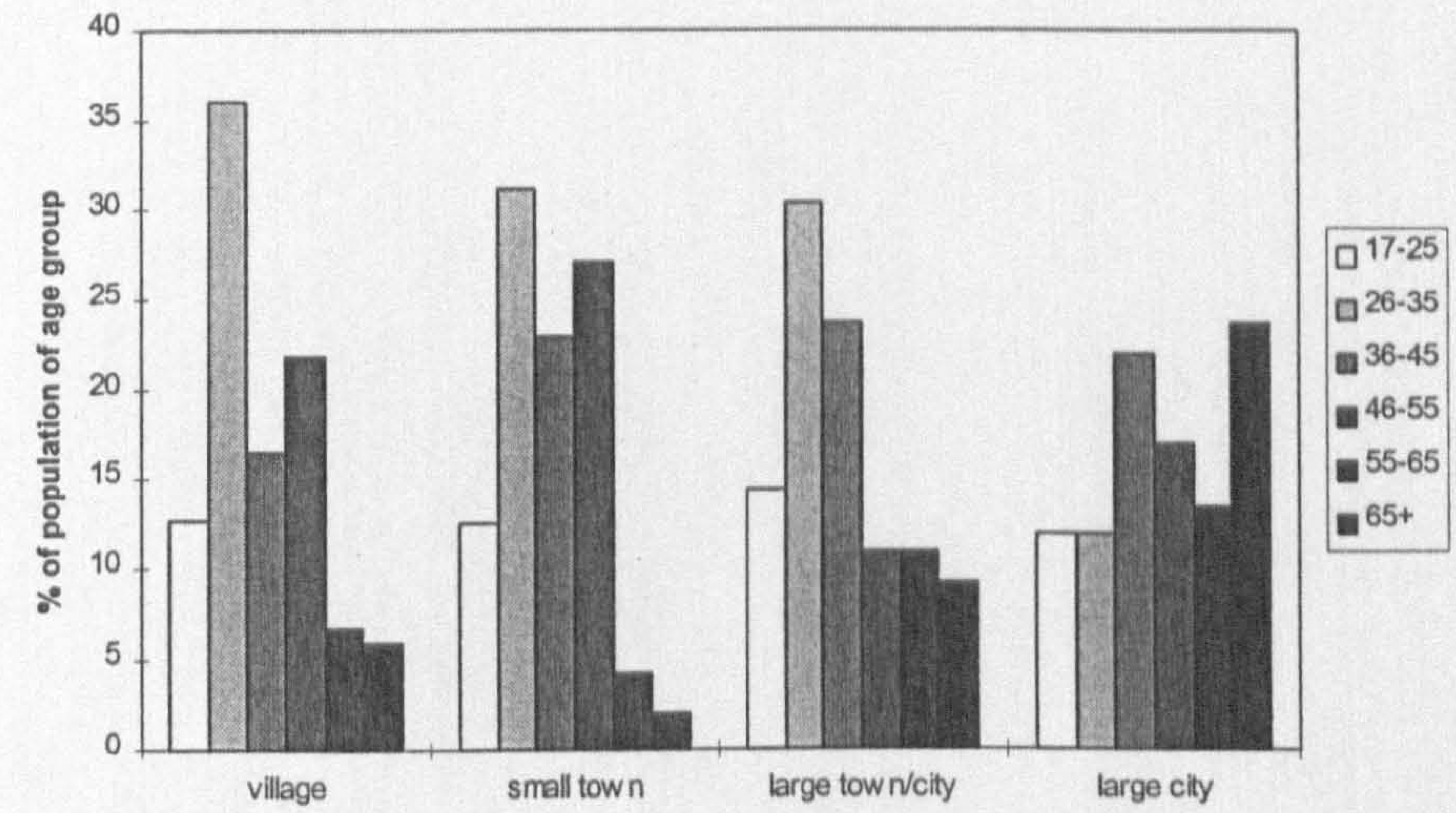


Figure 7.10 Age split by residential area

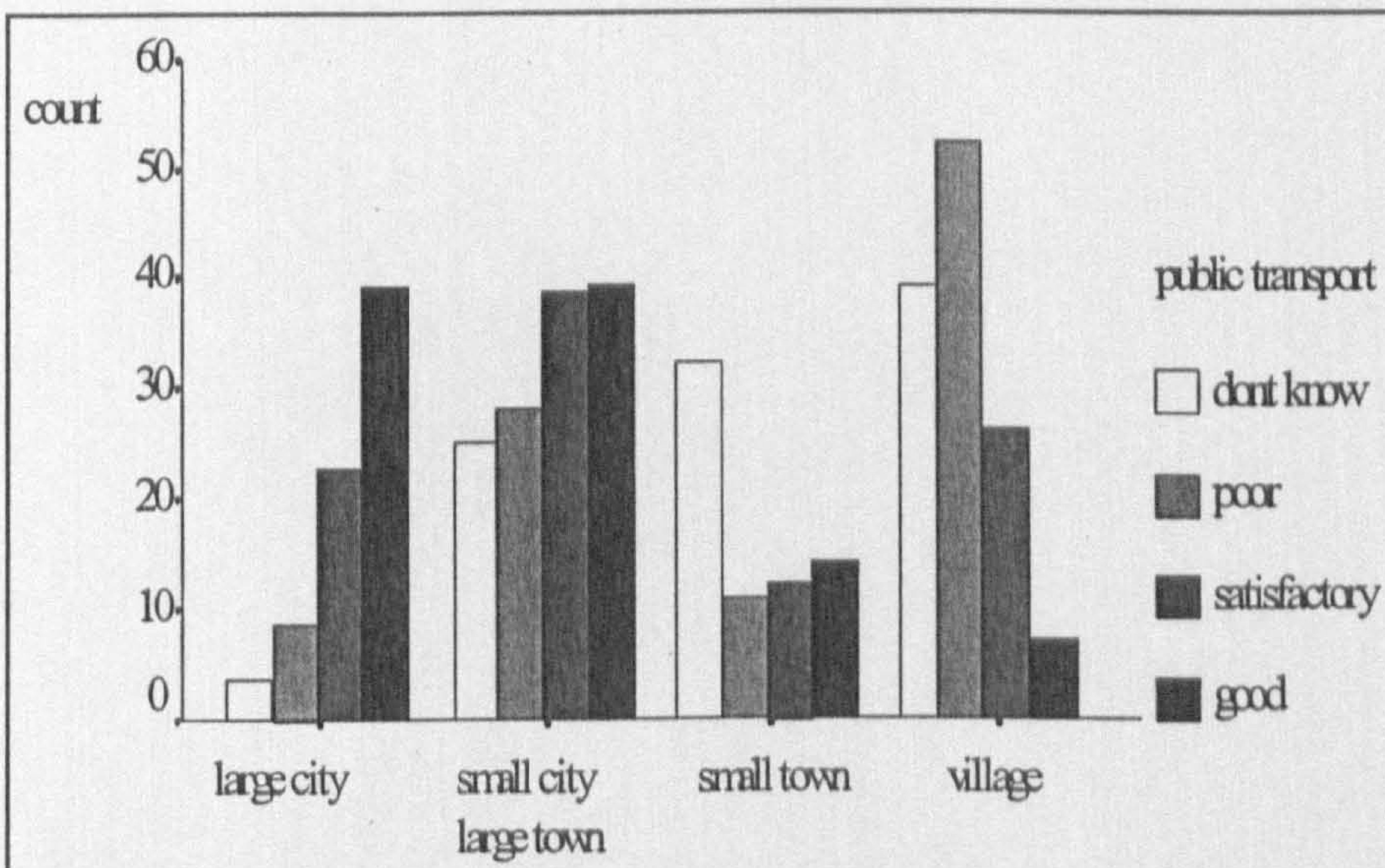


Figure 7.11: How public transport is rated in terms of residency

Figure 7.11 shows how the population rate public transport and is divided according to the size of conurbation in which they live. Overall most respondents find public transport to be poor (see Figure 7.7). However, the percentage from villages rating public transport as poor (i.e. does not well fit their needs) is high compared to those from cities. Those who are from a large city do consider overall, public transport to be good. Those from small cities tend to be of a more mixed opinion. Those respondents that have no idea of what public transport is like (i.e. never use it) are represented by a larger percentage as the size of the conurbation decreases.

A notable point here is the large number of don't knows resident in the village populations.

7.3.2.3 How often do you drive?

The only relationship to show up in relation to how often a respondent drives, was that of size of residential area (Figure 7.12). While it is noted however that resident type and satisfaction with public transport were linked (especially to the don't knows), the Pearson correlation showed no relationships between rating of public transport and how often a respondent drives. This may be due to the number of respondents who considered public transport to be good or didn't know, and who actually used public transport, were so low that no meaningful statistics could be derived from this sample.

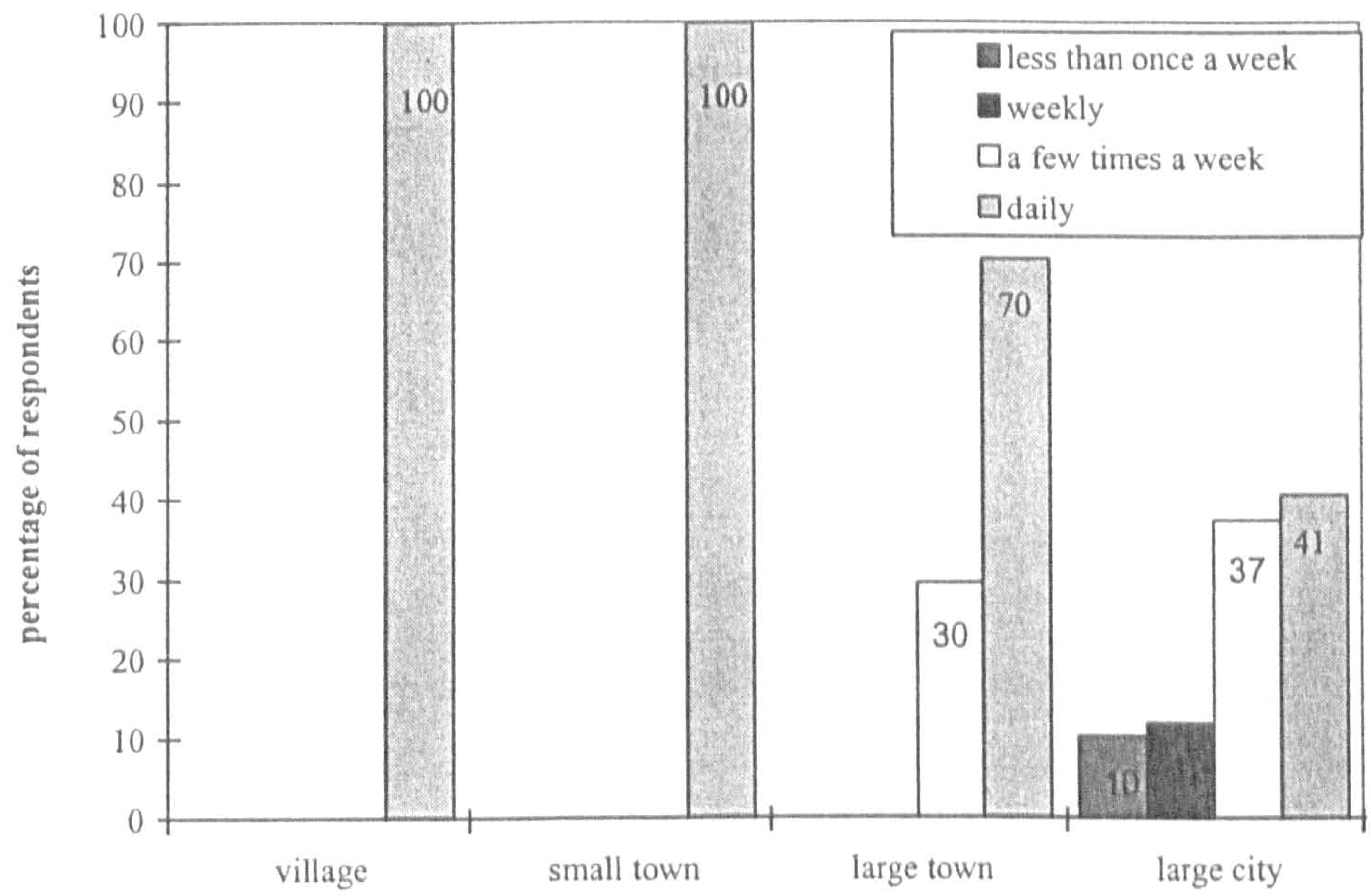


Figure 7.12: shows the relationship between how often people drive and the size of their area of residence.

7.3.2.4 How long driving

The age group of the respondent is strongly associated with the time the respondent has been driving. This is expected and the only strong association between the independent variables under investigation that is present above the 99% confidence level. The strength, high probability and the bivariate nature of this relationship allows for one of these variables to be dropped in any subsiquent analysis (SPSS 1996), therefore the variable how long driving will not be used in the ANOVA analyses but will be replaced by age group.

From section 7.3.1 it can be seen that the relationship of *Satisfaction with public transport* and *size of residential area* shows the only marked correlation. However, the value of this association is not very high (0.16) and is unlikely to have a great effect on the ANOVA tests carried out in the next section. No other association is shown to be likely over the 99% level other than how long driving (with gender). As has been noted this last variable has been discounted.

The lack of any other strong association between the independent variables shown in Table 7-1 indicates that single factor ANOVA analysis is justified to illustrate the relationship between the dependent and independent variables.

7.3.3 Relative and Comparative Importance of Needs and Desires Surrounding The Use of the Private Car.

Figure 7.13 shows the average score of importance, from all questionnaires, for given aspects of utility expressed through the quantitative data (these are illustrated by quotes in appendix 4.4). It can be seen that the importance attached to each of these utilities can be divided into three groups. The first of these groups is rated highly across the sample and consists of *access* and *flexibility*. The second group is rated moderately high and includes *privacy*, *comfort*, *personal security*, and *cost* (the function at which most contemporary policies are aimed) respectively. The next two utility functions are of less importance (av. 1.5 -2.5) these are *being in control of the vehicle* and *status*. The way these expressions of utility break down in term of each sub-cultural variable is described below.

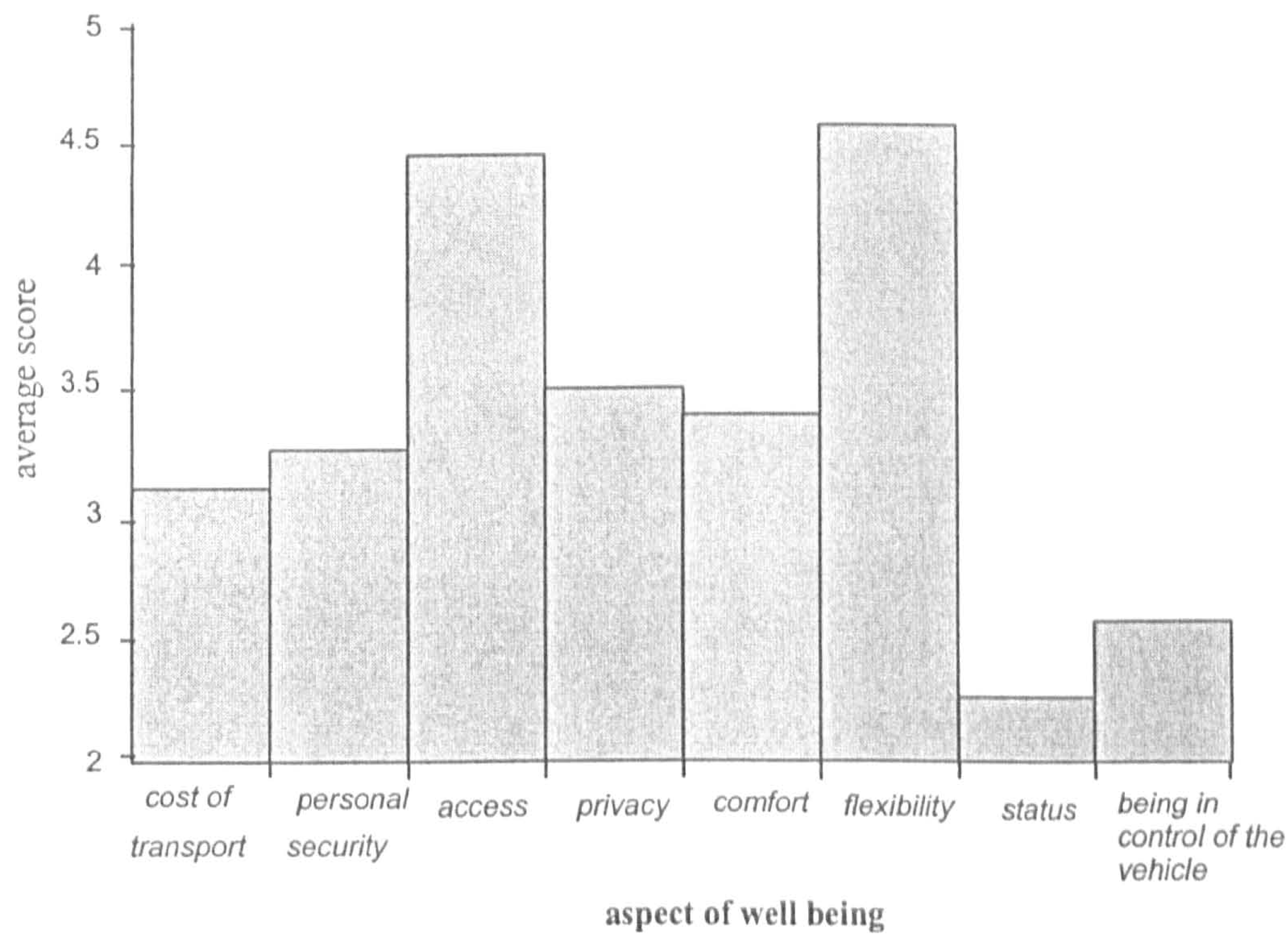


Figure 7.13: Relevant importance of utility functions for the whole population

7.3.3.1 Test for association between dependent and independent variables: Comparison of Means

The results shown in Table 7-2 are summaries of the a comparison of means test used as a first phase test for associations between independent and dependent variables. The raw tables generated by each comparison of means tests can be found in appendix 4.1., those identified as relevant in Table 7-2 are highlighted.

The actual nature of any possible associations identified in this stage of the analysis will be explored further by a second phase test using a single factor ANOVA and associated LSD analysis.

Table 7-2: Possible associations identified by low level comparison of means test

	Gender	Age	economic grading	residence type	rating of public transport
Access				√	
Comfort		√	√		
Cost		√	√	√	√
being in Control		√			
Flexibility		√	√	√	
Security	√	√	√	√	√
Privacy		√			
Status			√	√	√

7.3.3.2 Gender. (appendix 4, tables 4.1.1 to 4.1.7)

The comparison of means tests indicated the following results:

- *Personal security* shows a strong relationship to the respondent's gender. The overall mean is 3.2 but the mean value for female respondents is nearly twice that of males. It is considered that the relationship between value placed on *personal security* and a person's gender is clearly demonstrated without the need for further analysis.

- *Access, comfort, cost of transport, being in control of the vehicle, flexibility, privacy* and *status* do not appear to be associated with the gender of the respondent..

7.3.3.3 Age Group (appendix 4 tables 4.1-8 to 4.1-16)

- The importance placed on *flexibility, status, personal security, being in control of a vehicle,* may be influenced by the age, these factors will be tested with a one-way ANOVA test.

- *Access* does not appear to be dependent on the age group to which the respondent belongs. It is considered very but equally important for all age groups.

- *Comfort* and *cost of transport* appear to be equally important regardless of age group. However, there is a wide range in responses (i.e. a high standard deviation) within the 26-35 and the 65+ age groups compared to other age groups. This variation will be tested using an ANOVA.

7.3.3.4 Economic Grading (appendix 4 tables 4.1-17 to 4.1-24)

- *Cost of transport* was related to economic grading. This was expected and supports the system used for assigning economic grading. The nature of this association is explored in more depth using the ANOVA test.

- *Flexibility* showed little variation with respect to economic grading. This feature of utility is considered highly between each group. However there is a high standard deviation within group 2 and very low one in group 1 so this association will be tested using an ANOVA.
- *Comfort* did not vary significantly with respect to economic grading of the respondent. However, there is a trend from a mean of 3.5 in the lowest economic category, to 3 in the mid range and 2.7 in the upper range - a trend that merits further analysis.
- *Personal security* means did not vary greatly depending on economic grading. However, the difference between group 1 and group 2 is high compared to other groups and justifies further testing.
- *Access, being in control of the vehicle,* and *status* did not vary with respect to economic grading of the respondent.

7.3.3.5 Size of Residential area (appendix 4 tables 4.1-15 to 4.1-32)

- *Access, being in control of the vehicle, flexibility, personal security,* and *status* show variation in the degree of importance placed on them with respect to the conurbation size in which the respondents live. These variations qualify for further testing.
- *Costs* at first sight seems to be fairly uniform with respect to residence type However it may be less of an issue to those living in large cities. This may be due either to factors concerning the distances needed to be travelled by residents in different localities or the relative incomes of people who live in the city compared to other places, and will be tested further using a one-way ANOVA to test for significance.
- *Comfort* as an issue does not vary significantly depending on size of conurbation, neither is there a significant variation in deviation of response.

7.3.3.6 Rating Given to Public Transport (appendix 4, table 4.1.33-4.1.40)

- *Cost, status* and *personal security* do indicate some variability when compared with a respondent's rating of public transport.
- *Access, comfort, the need to be in control of the vehicle, flexibility* and *privacy* show little variation depending on the respondents rating of public transport.

7.3.4 Test for Association Between Dependent and Independent Variables: ANOVA and LSD Results

The following results are the outcomes of the ANOVA tests (frame7.1) between the independent and dependent variables identified above. Relevant indicators are assumed at 90 and 95% confidence levels and the nature of the association is illustrated by accompanying post hoc tests for least significant difference (LSD).

Table 7-3 is a summary the ANOVA tests results and shows any identified association between the independent variables (columns) and the dependent (rows).

Table 7-3: Significant associations between independent and dependent variables.

	gender	age	residency type	economic grading	rating given to local public transport
access			√		
comfort					
cost		√	√	√	√
control		√			
security	√		√		
flexibility		√	√		
privacy		√		√	
status		√	√	√	√

7.3.4.1 Age (Appendix 4 tables 4.2.1-4.2.11)

- There was a 99.3% likelihood that there is a difference in the importance placed on *cost* depending on the age of the respondent. The test for least significant difference (LSD) indicated importance placed on *cost* varies specifically between 65+ age group who overall placed less importance on the issue of cost than the youngest two groups (those under 35) or the age group 56-65. An interesting feature is that the lowest and highest means are found in adjacent age groups.
- *Being in control of the vehicle* is indicated by the ANOVA test to be associated with a respondent's age at the 99.7% confidence level. This is a significant result and where one looks at the LSD analysis of this association, one can see that there is a major distinction between 17-25 year olds groups who consider this feature as being far more important than the others.
- *Flexibility* as an issue does appear to vary depending on the age group of the respondent at a 99.5% confidence level. The LSD test indicates that *flexibility* seems to be less important to those in age group six than those in the other groups.
- *Personal security, comfort* and *access* did not show association depending on age group at the 95% or 90% confidence levels. The LSD test also indicated no association between these variables.
- *Privacy* as an issue, shows a significant association, in this case a 98% probability, with the respondent's age group. The LSD test indicates that, as with *being in control of the vehicle*, it is the youngest age group that significantly rates this value more highly than the others.
- The value placed on *status* showed association with the age group of the respondent at the 99.9% confidence level. The overall association would seem to

be a decrease in importance placed on this feature with increasing age. However, the most significant difference is between age group 1 (17 -25 years olds) and all the others.

7.3.4.2 Economic Grading (Appendix 4 tables 4.2.12-4.2.19)

- *Cost* as an issue was associated with the variable economic grading at the 100% confidence. The LSD test indicated that within these groups the importance placed on cost varies in such a way that the lower economic gradings consider the cost as more important than the higher. This is as would be expected. However, there was also a slight reverse trend shown in the higher gradings between importance of cost as a function.
- *Privacy* was found to be associated with the economic grading given to the respondents at a 96% confidence level. This difference lies in the fact that those assigned to the top two groups seems to place a significantly higher importance of this feature than the lower groups.
- *Status* is associated with the economic grading of the respondent with a 97% probability level. The LSD illustrates the nature of this association and shows that respondents in the group of over 15,000 rate this utility more highly in respect to the other groups.
- *Personal security*, and *flexibility* did not show evidence of significant association with the economic grading of the respondent at the 95% or 90% confidence levels.

7.3.4.3 Size of Residential Area (Appendix 4 tables 4.2.20-4.2.28)

- *Cost* as an issue varies with a 94.8% probability (this is relatively low but higher than the 90% cut off level for the ANOVA test) depending on the size of conurbation in which the respondent lives. The LSD test indicated that the respondents living in villages and small towns tend to place more importance on this feature than those living in cities and large towns.
- The importance of *personal security* may vary depending on the variable residential area of the respondent (94.5% see above) in that those who live in a city are less concerned about security than others. However, when one considers the association between dependent variables (Figure 7.9) the suspicion arises that the variation in means between residential area and security may be due to the uneven representation of male respondents from cities, especially if one considers the LSD analysis which identifies city dwellers to be the variant within this group.
- *Access* is considered very important compared to most other aspects of well being and as a whole equally highly by all respondents regardless of sub-grouping. The ANOVA test, however, indicated that there is a 100% certainty that the importance placed on this utility will differ in terms of the size of the conurbation in which the respondent lives. The LSD test indicated that the groups living in small towns and villages place more importance on access than those living in cities and large towns. Indeed on a scale of 1 to 5 (5 being the most important) the average score for all respondents from a small town is 4.9.

- There is a probability (98%) that the importance placed on *flexibility* as a utility function of using private transport is associated with the type of conurbation in which the respondent lives. The LSD test indicated that those from villages and small towns place a higher importance on than those in cities and larger towns.

7.3.4.4 How the respondent rates public transport in their area.

How the respondent rates public transport in their area is different to the other independent variables in that is a category rather than a group of people. It aims to represent a respondent's subjective opinion rather than reflecting their externally set cultural grouping. The result is that this sub group produced highly skewed results (see figure 6.8) from a random sample. This may mean any ANOVA results produced are, to a great extent, invalid. However the following results are included since they may be indicative of how the rating given to the utility functions vary with respect to this variable. For this reason the 90% confidence limit will be dropped as an indicator of association.

- *Cost* is associated with how a respondents rate public transport at a 99.9% confidence level. The LSD test indicated that this variation occurs since those who rate public transport as poor tend to value cost slightly higher than the others.
- *Status* was associated with how the respondent rated their local public transport, at the 97% confidence level. The LSD test indicated that the nature of this relationship was that those respondents that stated that they did not know what their local public transport was like (group 4) tended to rate the utility of status higher than those who did.
- *Personal security* did not show any relationship with how the respondent values public transport at the 95% confidence level and neither was their any relationship detected via the LSD test

7.3.5 Qualitative Data Analysis

The following description of the aspects of well being derived from private car use is derrived at by abstracting, through key-word analysis, the replies to the question "*do you prefer the use of private transport to public, and if so why?*. Raw data can be found in appendix 4.3.

7.3.5.1 Do people prefer private transport to public?

The response to the question "do you prefer private transport to public" showed that 89% of respondents do prefer to use their own vehicle as opposed to only 8% who public transport (the remaining respondents consist of 'don't knows'. Furthermore, of the people who considered public transport to be preferable to private, over 43% used a private car on a daily basis (see Figure 7.14.)

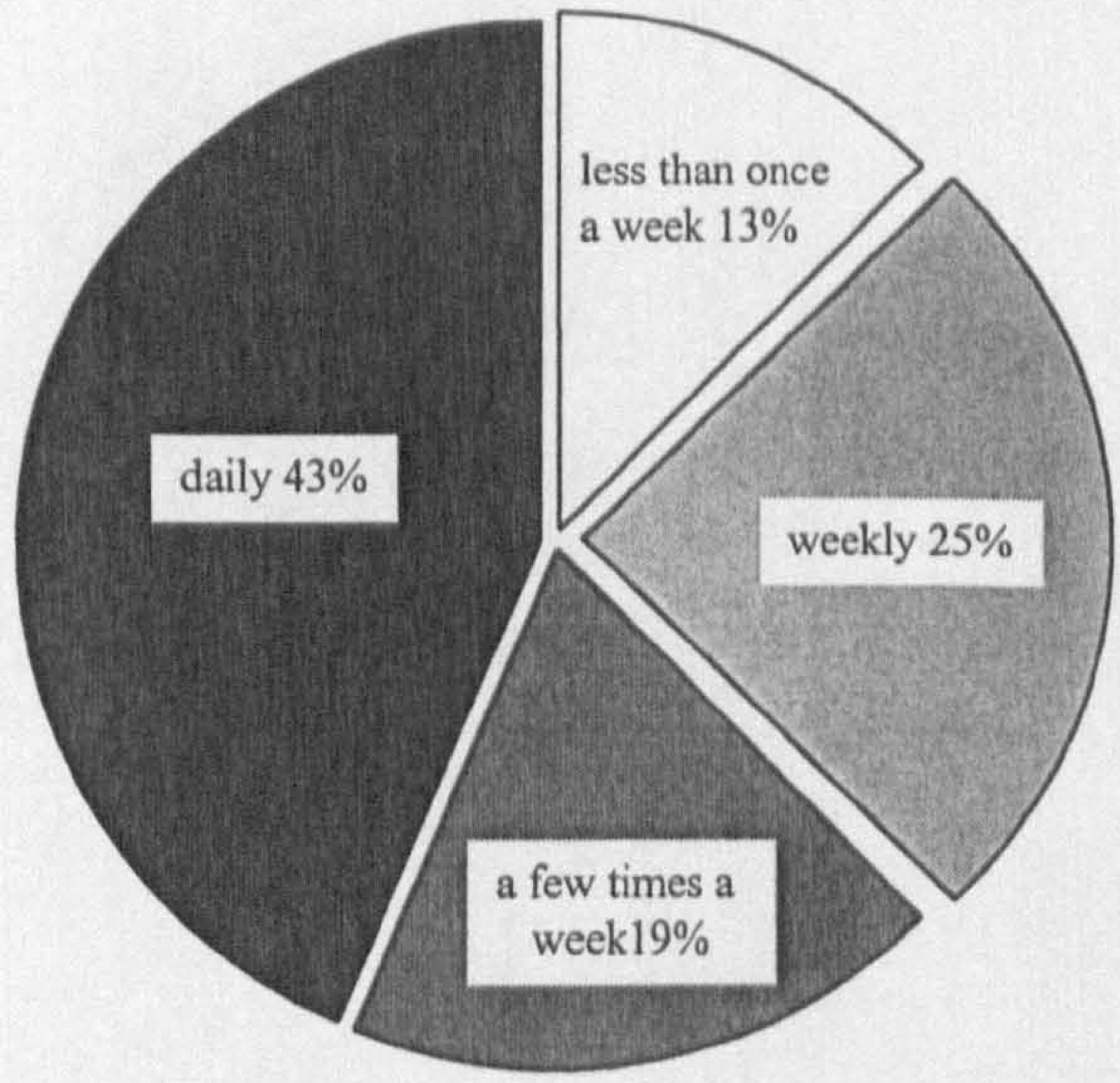


Figure 7.14: How often respondents who expressed a preference for public transport actually use private

The reasons given by drivers who elaborated on why they drive daily but would prefer public transport are shown in Table 7-4.

Table 7-4: Responses from people who stated that they prefer public transport but use private on a daily basis.

"No I prefer public in theory but not practice."
"No I prefer public, more environmentally friendly."
"No I need to use private transport because there is no alternative, if I worked locally I would use public."
"No I'd rather use public if it was there."
"No I don't like using the car would prefer public transport to be better."
"No I need to use private transport because there is no alternative, if I worked locally I would use public."
"No but the problem of geographical diversity of the objective journey makes the universal use of public transport impossible, particularly from a semi-rural home base"
" However the high cost and the infrequency of public transport doesn't allow me to use it."
"No not if it is cheaper and available."
"No, prefer public but it is not at present a viable alternative."
"No I drive under duress because public transport is crap."
"No I have always preferred public transport to private when it is efficient. Currently however public transport takes too long: 2 hours rather than 40 minutes. My company car and petrol are free."

The overall impression one gets from these results is that most people regard private transport as much more suitable when taking into account their personal needs, wants and opinions, even when the respondent has a preference for the idea of public transport. Overall private transport has become the central feature of how the respondents meet their needs and wishes regarding transport. The question then arises as to why people use private transport, what is the nature of these wishes and needs?

7.3.6 Why do People Need Private Transport

Replies to this question were reduced to two sets of keywords (Table 7-5.)

Table 7-5: Keywords used in qualitative analysis

what did respondents use transport use.	why do they use it	
work	cost	flexibility
shopping	security	status
carrying children	access	reliability
visiting family/friends	privacy	speed
leisure	comfort	

Figure 7.15 shows the respondent's comments as to the main purpose for which they use private transport in their everyday lives, and breaks down this response in terms of the respondent's sex.

While the majority of the respondents used their car for work this is only just over 50% for the whole population, 48% of the respondents using it for other purposes, a figure which is higher for females than males. The response indicates that the needs and wants fulfilled by the use of a private motor car are wide ranging and include features such as: facilitating employment as well as out-of-town and bulk shopping (a main economic saving over local shopping in many cases); allowing children to attend school; to maintaining social and family contacts and taking part in recreational activities.

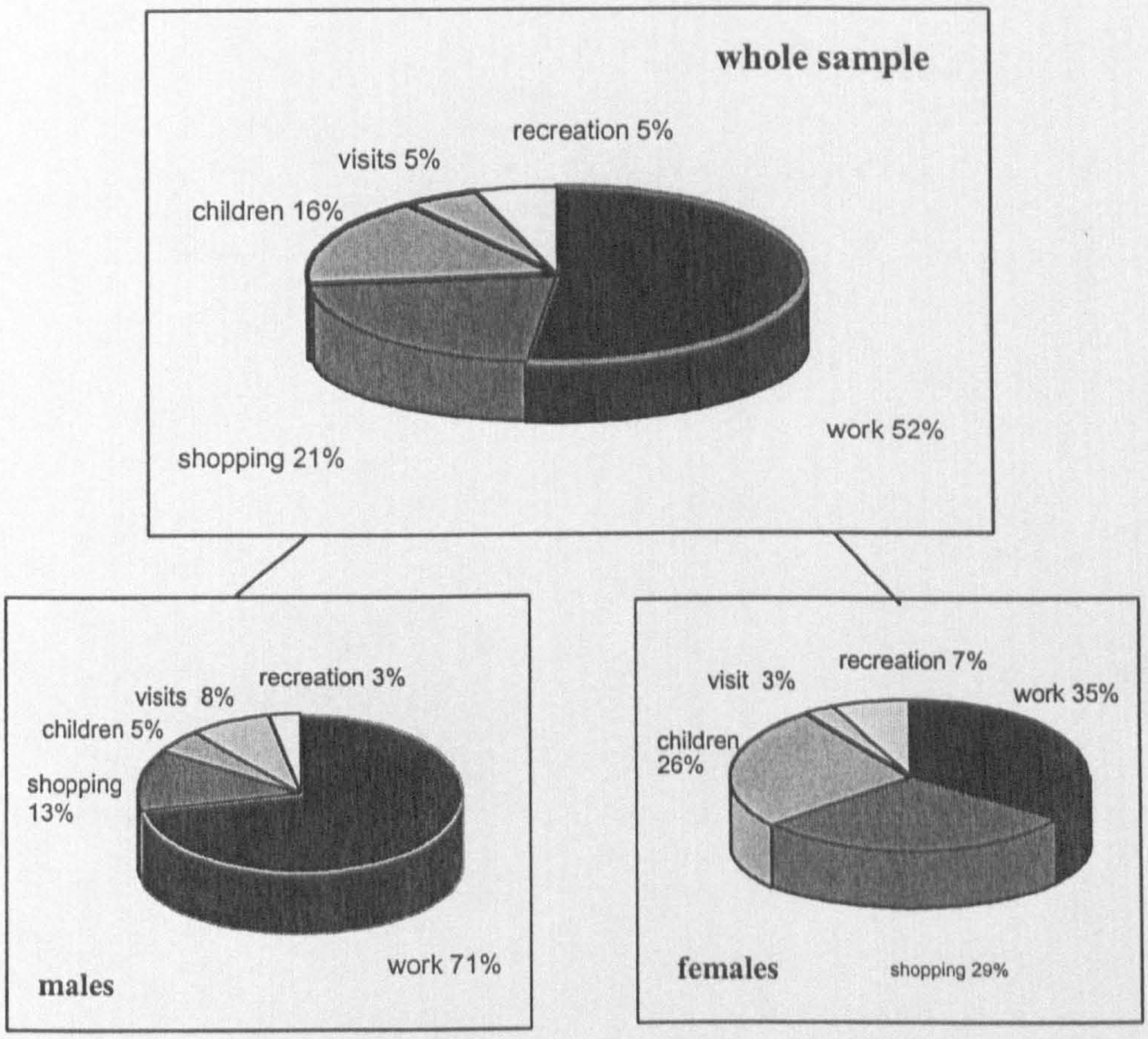


Figure 7.15: Statements of why surveyed people drive broken down into female and male responses

Furthermore, when one looks at the same issue divided on the basis of the size of residential area from which respondents come, (Figure 7.16) one can see there is also a great degree of variation in the reason why people say they need to use a motor-car.

In the case of cities, work is third place to shopping and recreation in terms of stated reason for using the motor-car. In large towns recreational use is of much less importance than in cities, while usage of the motor-car for work journeys and shopping trips are nearly equally common stated uses. However when one looks at the smaller conurbation one can see that work use is by far the greatest reason for using private transport, while recreation is a much less stated reason in villages and small towns than in cities.

However it must be remembered at this point that there was a high representation of the 65+ age group in the sample taken from the city which may skew the results away from employment towards recreation. However, the point remains that different populations in different areas may have different requirements regarding transport.

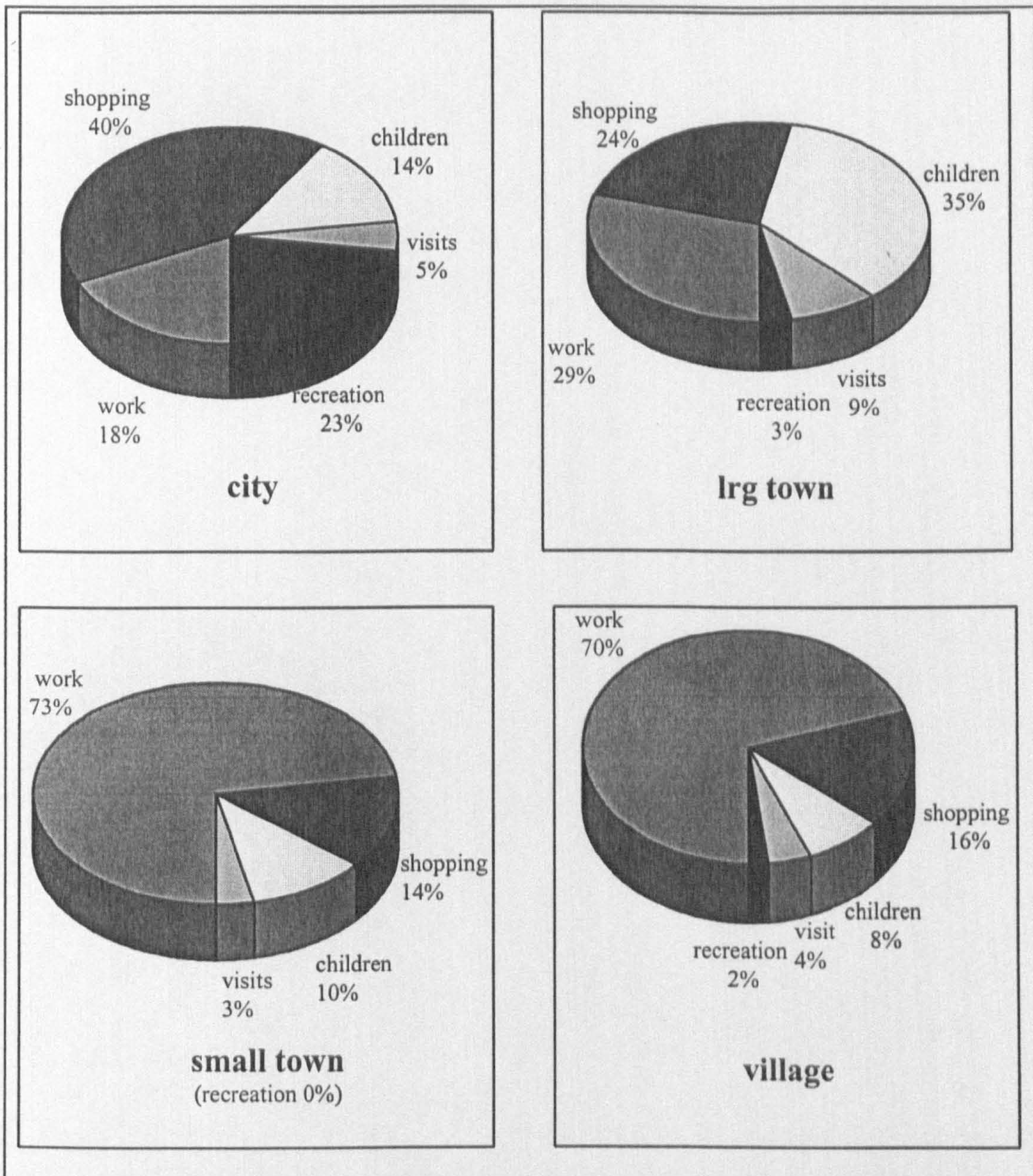


Figure 7.16: Reasons why people drive separated into place of residence

7.3.7 Why Do People Like Private Transport?

The second basis on which these responses were analysed was on the expressions of why respondents prefer to use private transport over public. The responses are shown in Figure 7.17.

Overall the responses support the findings from the qualitative analysis since they show a similar pattern to that illustrated in Figure 7.13. The most commonly mentioned features were flexibility and access. The next group of responses is similar to that mentioned previously in 7.3.3.1. However, the analysis of open responses indicates that cost is considered as more important than security or comfort. Furthermore a new feature of *speed* has been identified as important.

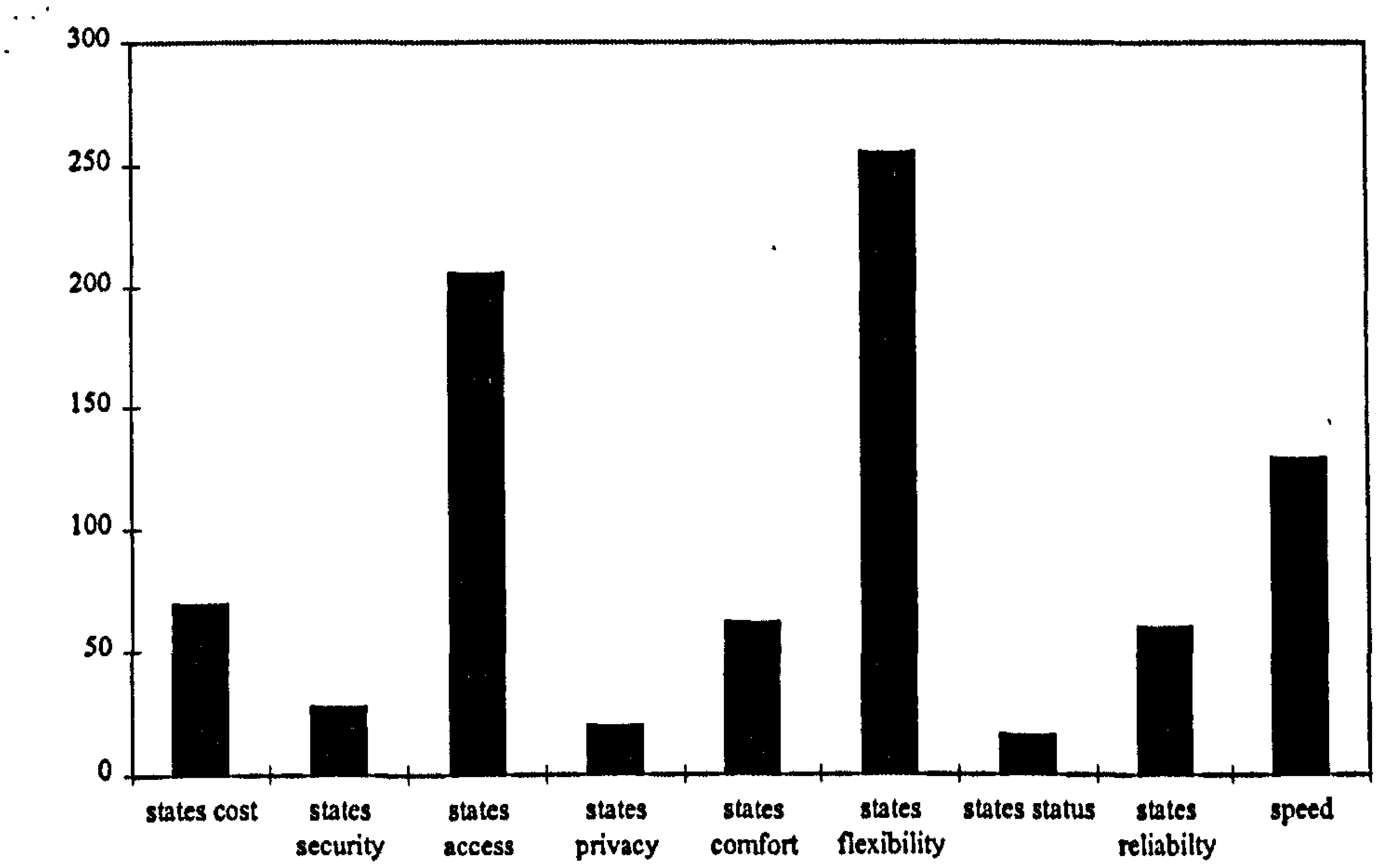


Figure 7.17: requirements of transport: free statements.

When one looks at the actual statements relating to cost two features can be seen: firstly, that there is a wide ranging perception that the use of private transport is cheaper than public and secondly cost is often measured in conjunction with other features. These two features are shown in Table 7-6, a list of statements relating to cost.

7.4 Discussion

The following discussion of the results will follow the format laid out in the aims of the chapter. It must be remembered that the analysis presented in this chapter is not an in depth ethnographic study of motorists in the south central area of England, but rather aims to illustrate how some of the features of the social aspects of the production of ozone precursors pose problems for the present air quality management framework. The stress on the social aspects of car driving is a reflection of the fact that the UK National Air Quality Strategy (DoE, 1997) identified the present wide use of the private car a major concern in the management of UK air quality. That this is especially relevant with regards to tropospheric ozone in the south east has been discussed in chapter 3.

The first aim of the analysis was to investigate how representative the surveyed sample was of the driving population as a whole.

7.4.1 A review of the population sample

The gender composition of the sample was slightly skewed reflecting a bias in favour of males among the driving population as a whole. The age make-up of the sample population was seen to be close to normally distributed as would be expected from a range of young to old where the young age is cut off by not being qualified to drive and the latter by health and mortality.

The breakdown of the sample's car ownership in terms of economic make-up is shown in Figure 7.5. The majority of the population belong to the £3-6,000 and under category. The highest economic groups are represented by less than 10% of the sample and it is a slightly skewed in favour of the lower end of the market (i.e. the mode is slightly of less cost than the mean) reflecting the make-up of the UK population as a whole (Coleman and Salt 1992).

The population distribution with regard to size of residence showed a large representation from villages and small cities/large towns (Figure 7.6). However this is to be expected from the sampling area which centred on Bedfordshire, one of the most rural counties in the UK.

Table 7-6: Example replies to the question "Do you prefer private transport to public? if so why" that refer to cost.

"Yes public is unreliable and at times inconvenient, it is more expensive for a poorer level of service than private."
"Yes it's cheaper and public transport is not reliable."
"Yes public transport is unsafe and expensive."
"I use a small car since once it's bought it is cheaper."
"Yes cheaper once you have a car and more comfortable as well as safer."
"Yes more flexible and cheaper."
"Yes cheaper once you have the car and much more convenient."
"Yes it is cheaper and more convenient than public and saves me about 2 hours on my working day."
"Yes greater flexibility and is cheaper especially with kids."
"Yes buses are not a good service & expensive, need to get to St Ives -shop and pension, I like to drive, cost is important -retired."
"Yes prices for public transport in the UK are ridiculous, you get to Glasgow for £29 but London costs £25, where is the relation."
"Yes public transport is unreliable in timing and seemingly expensive."
"Yes much faster, cheaper (once you have a car) more comfortable, safer more pleasant."
"Yes cheaper for me and my two children"
"Yes, it is cheaper. Only petrol costs."
"Yes, mainly because of speed and cost, i.e. if. I travel to a school in Brookmans Park-20-25 minutes by car, public transport would take at least twice as long, once you have paid the basic costs of the car it is generally cheaper than rail."

Associations between sample sub-groups were not strong except for the how long a person had been driving with their age (this was to be expected) as well as with their gender. The latter association reflects a well recorded discrepancy in the age of gaining a driving licence between males and females (Evens, 1996). The only other notable association is between age group and residential area in that of the areas sampled there seemed to be a large representation of the over 65 age group from London (Figure 7.3) This may be a reflection of the population in the central area of London or may be a sampling error and must be borne in mind.

Overall, other than the population distribution the sample appears to be a good representation of the driving public at large and the population distribution is representative of the area under study. The associations that were present between the population sub-groupings were not strong (over .25) and allowed for ANOVA analysis (SPSS 1996).

The next aim of the study was to assess the needs and desires of the population in the south/central area of the UK and to identify the extent to which these needs and desires could be met by private and public transport.

7.4.2 An assessment of needs and desires with regards to mobility.

The features of mobility that the population considered important can be divided into three groups. The first of these groups is rated highly across the sample and consists of *access* and *flexibility* (with an average of around 4.5 from a score range of 1 to 5). From the analysis of the quantitative data these features are related equally highly but the function of flexibility was mentioned more often than access in by the public when responding to the open question.

The second group were rated as less but still moderately important and include *privacy, comfort, personal security,* and *cost* respectively. However in response to the open question respondents mentioned cost more than the other features in this second group. They also added a function of speed (Figure 7.15)

The reason why cost is rated higher than the other functions of this group may be due to the fact that by asking the respondent a open question, the results show a more comparative view of the needs that private transport fulfils (Bryman, 1992). The quantitative data set recorded the relative degree of concern and not its degree of importance, whereas the qualitative data set measured the presence or absence of the concern. This may mean that while respondents have cost as a common concern it is often of lesser importance when other concerns exist.

The cost benefits of the motor car over public transport are overall considered to be moderately important with regards to the other identified features. However, of the mid range important features (Figure 7.12) it is not dominant and it is overall less important than access or flexibility.

This is important when one considers that market mechanisms have been identified as the major tool for weaning people away from private transport, a feature discussed in chapter 4. The basis for this approach is that at present it is generally considered that the use of the private car is for many cases cheaper than public transport, a perception that is supported in Table 7-6. Therefore a main tool of national as well as local government air quality management as laid out in the UK National Air Quality Strategy (DoE, 1997) concerns the imposition of financial disincentives on using the motor-car as a form of transport.

However, it is not the main concern of respondents when choosing a form of transport in comparison to nearly all other functions except for status and being in control of the vehicle. Therefore it is useful at this point to assess how well the public believe that in the absence of cost issues, public transport can fulfill these other needs.

7.4.3 How well does public transport serve the needs and desires of the sample population?

Since it can be assumed that the survey is fairly representative of the UK population in the south central area of the United Kingdom, and that it is apparent from results that many people rate public transport as merely satisfactory or poor, it may be surmised that the present provision of public transport is failing to meet the needs and desires of the public. It has also been shown that the uptake of public transport is poor even in areas where the price of public transport is vastly reduced (Air Health Strategy, January, 1997).

An explanation as to why this may be the case is that while cost is a concern with regard to public transport it is not the only, or even a major, concern. That this is the case was shown by the strong association between *size of residential area* and *"how often do you drive"*. The correlation between these variables is strongly positive i.e. the smaller the residential location the more often a respondent tends to drive. This relationship was shown clearly where 100% of respondents from villages and small towns drive on a daily basis. However residents from large towns are split between daily driving (70%) and driving a few times a week (30%).

When one considers this relationship and the high values placed on access and flexibility one may deduce that for many people present public transport provision is not flexible or accessible enough for them to rely on in their everyday lives, regardless of cost, especially in those areas where there are more dispersed living patterns.

This case is supported when one considers not only the difference in reliance on private transport between the larger and smaller conurbations, but on the variation in why private transport is used. Figure 7.11 shows this clearly, where many residents of the smaller conurbation use public transport for work on a regular basis. The impracticality of public transport for many respondents is supported by the fact that that of the 8% of people who expressed a preference for public transport over one third of these expressed the view that this was more of an idealistic viewpoint but that they used mainly private transport due to the impracticality of the present public transport sector. This feature was illustrated in Figure 7.14 that shows that of those respondents who said they preferred the idea of *public* transport nearly half actually use a private car on a daily basis and well over half drive a car more than once a week.

The fact that so few people use or want to use public transport (even if they express a hypothetical preference for it) indicates that there is a need to more closely match the provision of public transport with the requirements of the population and that these requirements are not just restricted to questions of affordability. Public transport provision needs to be tailored to the desire for flexible, accessible, safe and comfortable transportation. That this is not the case at present is illustrated in Table 7-4 (Responses from people who stated that they prefer public transport but use private on a daily basis).

That there are requirements surrounding mobility that are themselves a product of the availability of private transport is a point made in by Wagener (1994) and Taylor (1993) on how the use of the private motor vehicle has become an intrinsic feature of peoples lives it has facilitated more disperse living and activity patterns but constrains people's transport options to this mode of transport. In the words of Vickers (1984)

> *"The development of the automobile did more than provide us with a new means to satisfy our needs. It set new needs, new expectations, new norms of mobility, even new limits of unacceptable mobility."*

These *new limits* of unacceptable mobility with regard to public transport go well beyond the question of cost, as is illustrated by the verbal responses of those who drive on a daily basis (Table 7-7) Table 7-7: Responses in response to the question do you prefer private to public transport.

Furthermore while the respondents from smaller conurbations drive the most, they also show the least knowledge of what local public transport provision is like (Figure 7.11). This may indicate that the more often a respondent drives the more likely it is that they do not to know what public transport is actually like. In this way using the private motor-car may be a self reinforcing pattern of behaviour.

If a change in this behaviour is to be addressed it will require a conscious effort on the part of the body promoting private transport to communicate the reasons why to the car-driving population. These reasons must meet the needs and desires of the population that they are aimed at if people are expected to change their behaviour voluntarily.

These needs and desires permeate all aspects of an individual's life, from allowing them to continue living and working in the same place, to maintaining social and family contacts, allowing shopping patterns that fit into personal life agendas to allowing a feeling of safety in a (perceived) ever more dangerous world (note the high value placed on security by female respondents in section 7.3.3.2). The overall indication is that if the public is to be weaned away from the use of the private motor-car then economic incentives or disincentives alone will be ineffective. There is a need for a push/pull approach to changing driving behaviour that can identify aspects of public transport that are needed and desired by the population and communicate that these issues have been addressed to that population.

The car driving public need wooing towards the use of public transport and public transport needs to show that it can fulfil the requirements and needs provided for by the private car.

However the issue at this point is not complete. It has been shown that there are a wide range of needs and desires connected to car use that public transport provision at present does not address, and indeed some of these it may never be able to address. However the results presented in this chapter show that these needs and desires are not qualitatively or quantitatively consistent throughout the region under study. This is the next feature dealt with.

Table 7-7: Responses to the question do you prefer private to public transport from people who drive daily

Yes access and convenience
Yes-need it for work-self employed financial consultant
Yes car is easier and more convenient, shopping etc.
Yes public transport is dirty and inconvenient
Yes for reasons of comfort and flexibility
Yes its necessary for work
Yes I need the car for work, for both getting there and meeting clients
Yes I need the car since I am registered disabled
Yes - I use it for work, petrol paid for
Yes-need it for work, public transport is no good
Yes car to get kids to school and shopping is shops in Daventry or Northampton
Yes public is unreliable and at times inconvenient, it is more expensive for a poorer level of service
Yes I'd prefer public if it was available but it isn't
Yes only option for work, and shopping
Yes public transport is poor, and unreliable and slow
Yes I'm disabled, otherwise id use public
Yes public transport in the UK is terrible
Yes rural bus service is poor and restricted and very slow
Yes cheaper and public transport is not reliable
Yes more convenient and direct
Yes convenience public transport isn't
Yes its convenient and I enjoy privacy
Yes I drive for a living
Yes for flexibility public transport is poor
Yes convenience I live in a village it would be difficult to go anywhere without a car
Yes convenient quicker
Yes job involves travelling to different places I need reliable and convenient transport
Yes flexibility and convenience, can make many small journeys at once
Yes private transport is more convenient. Public transport is unreliable and uncomfortable
Yes impossible to use public transport to get to work
Yes public transport is useless for picking up children and shopping for large items.
Yes no public transport goes to place I need to
Yes no adequate public transport
Yes absence of alternative transport
Yes can get from a-b and would have to change 2 buses and a train to get to work otherwise
Yes greater flexibility and is cheaper especially with kids
Yes because public transport is dirty
Yes I am a nurse and have to go to and from work often at unsociable hours
Yes convenience, timelines, moving large items
Yes while most places are accessible it would require at least one change of transport to get to the majority of places where I want to go. My car is also essential for my work, and the cost of public transport is high
Yes I don't like being treated like a sardine! When I go to use the tube I generally have to claim from the passengers charter at least once a week, what sort of service is this
Yes need it for work (the other side of Cambridge) not easy to get there by bus, anyway easier to get around
Cannot get to Woodhurst easily two buses a day, dreadful - not a service
Yes service to Bluntisham is useless, use the car to get around, don't use bike because the roads are unsafe, kids

7.4.4 An investigation into the variation in the value attached to the needs and desires surrounding private transport.

The results of the ANOVA analysis indicated that the linkage between the type and location of the respondent and the importance placed on needs and desires surrounding private transport are as follows:

- *Access* as a feature is identified as very important by the sample in general, however, it does also show variation with response to size of residential area, in that people from villages and small towns tend to rate this concern more than those from the larger conurbations. Indeed of all expressions of utility derived from the use of motor vehicles within any population sub-group, *accessibility* in regard to village residence scores the highest mean response.
- *Comfort* is rated moderately important by the whole population, but is shown to be of most importance to the oldest age group of respondents.
- *Being in control of the vehicle* was of lesser importance than most other aspects of utility except *status*. However, the importance given to this does vary with age. The youngest age group of respondents rate this feature more highly than the others and indeed rate this function nearly as high as they do *cost*.
- *Security* overall is expressed as of medium importance in the whole population compared to the other utility functions, although this feature does show the strongest variation across sub-group variables in that it is rated twice as important by female respondents as males. The average score given to this feature by females is comparable to the scores awarded to access and flexibility and far exceeds those awarded to cost. This function also shows variation with respect to the size of residential area of the respondent in that those from cities rate this feature as less important than those from other locations. However, this may be due to the under representation of females in that particular sub-group.
- The degree of importance attached to *cost* varies depending on the respondent's age, residential location, and economic grading. The youngest two age groups (17-35) and the second oldest rated this function higher than the others, whereas those respondents from small towns and villages stated it on average as more important than those from the larger urban areas. As would be expected those respondents from the higher income brackets view this function as less important than the lower ones.
- *Flexibility* varies depending on the age group of the respondent, in that the upper age group tend to view this feature as less important than the others. It is also rated more highly by those who live in the smaller conurbations. However, all age groups value this feature highly compared to other functions.
- *Privacy* is rated as of average importance compared to other utility functions and shows variation with regards to age and economic grading. The youngest and wealthiest drivers tend to rate this feature more highly than others.
- *Status* is considered to be of low importance to the population as a whole, but does vary depending on the respondent's age in that the younger drivers tend to view this feature as more important than the older (indeed for young males this feature was nearly as important as cost). The only other group who rate this feature highly are

residents of small towns who consider it as important as *being in control* of the vehicle.

Furthermore it was demonstrated that the needs and desires are not the only features that show this variation, but the reasons why people tend to drive a car also vary. This was shown with regards to the sex of the respondent and the size of the conurbation in which the respondent lives.

If one takes the premise that alternatives, if they are to appeal to the population in question, need to be tailored to the population's needs and desires (Ahuja, 1996), then this variation is not trivial. Rather it has major implication for the resolution at which policy is informed, designed and implemented.

Policies poorly aimed at the population may make their local environment more uncomfortable or even intolerable, a point identified in chapter 2 that may produce unaccounted for and negative consequences that may severely hamper the success of the policy or the social area as a whole. If policies are to be tailored to the population as a whole then it seems clear from these findings that they need to account for the variation in needs and desires by being designed as close to the population in terms of their locality as possible, and need to represent the views of a wide range of social groups.

7.5 Summary: the Implications for Management.

Clearly the benefits derived by the individual in society with regard to the use of the private motor car extend well beyond any perceived cost benefits that the use of the car has over the use of the public transport system. It is equally clear that as a whole the present system of public transport fails to meet many of these needs or desires that are satisfied by the use of the motor car.

The traditional approach of financial regulation and isolated local management of polluting behaviour (chapter 3.3.1) is no longer applicable to the major problems facing air quality management. The motor car has come to serve a wide variety of needs for a great many people in every day living. Any management plan aimed at providing an alternative to the reliance on private road transport must be both acceptable and relevant to the target population. In order to do this, alternatives must fulfil similar expectations and desires to those fulfilled currently by the private motor car. Otherwise, such alternatives will be subject to failure and may produce emergent results that are contradictory to the aim of improving the urban environment (Cannibal and Hadfield 1997, see appendix 1), for example by driving away potential investment in an area. This point was raised by a local authority transport engineer:[1]

> *"Counties now have new powers to restrict peak area traffic for instance in a case where there is high pollution levels - but this will result in them screwing up their town's economies - people would just go to Milton Keynes."*

The motor car has become a feature of modern living, not as a discrete activity but as a central component to how people carry out social and professional lives.

[1] the source of this data is described in chapter 4

Furthermore, it must be recognised that these desires and needs that the motor car fulfills are not a constant for the whole population and represent individual ideals and expectations that are in turn a product of their experience with their everyday environment and therefore show a series of cultural, spatial, and temporal variations. The data presented in this chapter illustrates how these parameters affect the qualitative and quantitative values placed on the use of the motor car and policies aimed at changing behaviour need to recognise this fact.

Any provision made to provide applicable and acceptable alternatives to the motor car must acknowledge the local variation in the aspects of well being that individuals derive from private transport use. This recognition may suggest that they must be set at a local level through mutual dialogue between the spatially relevant management authority and the population at which that policy is aimed. In the absence of such an approach, voluntary change in such an important activity is unlikely if the driving public are merely economically coerced out of driving. This coercion could lead to long term resentment within society (Hardin 1968), essentially alienating the very people on whose co-operation the policy maker depends for the aims of the policy to be met (O'Riorden, 1996).

Forced change by means of financial coercion may have far-reaching implications, such as political disfavour with respect to the implementing authority, public pressure to reduce the value placed on clean air, or avoidance of economic costs through activities such as tax avoidance or illegal parking, essentially encouraging individuals to break the contract on which society is based, (North, 1984).

Strategies to improve air quality in the United Kingdom need to recognise the nature of the source activity in society. Monitoring and mitigation in air quality management need not just tackle the reception and state of the biophysical system, but the motivations of individuals whose collective action is a cause of the source (see chapter 8). The implications for the present UK air quality management framework are discussed in the following chapter.

8. The Management of Tropospheric Ozone: Identifying The Strategic Gap

The history of air pollution management, detailed in chapter 4, shows an overtly strong reliance on technical panace. While often most appealing to the groups responsible for pollution does little to curtail the polluting activity, furthermore it tends to produce a situation where when one polluting activity is contained, values and attitudes to local air quality tend to remain the same and other polluting activities take their place.

However, the history of air quality legislation also shows that successful management of problems has often been achieved when the benefit of controls have been most clearly demonstrated to those the policy affects. This recognises the need described in chapter 2, to demonstrate to a population that change will benefit that populations environment as a whole recognising both the social and biophysical aspects of that environment. Policy needs to make clear the need and advantages of change while at the same time minimising the degradation to the life-styles of the people whose co-operation is needed to bring that change about. This requires a good understanding of the benefits, needs and desires surrounding the activities that need changing as well as methods of communication benefits to the population.

Policy needs to be designed at as close to the population as possible and needs to be able to identify the social requirements of that population. However, it has been shown in the previous chapter these requirements vary among sub-groups of even local populations and policy needs to represent this variation by recognising the needs and desires of a wide range of the public.

In addition to these features, the regional nature of tropospheric ozone, adds further problems. The successful management of this substance require a close regional co-ordination of policy and the ability to communicate these between different localities and different groups. This chapter reviews the ability of the present air quality management framework to achieve this in its present form, it asks:

Is there a strategic gap between this framework and the issue of tropospheric ozone?

> *"The experience of London has shown that even after ridding the city of life threatening sulphurous smogs by the mid 1960s, within two decades it was experiencing serious and worsening air pollution problems in the form of photochemical pollutants, which are more complex and difficult to eliminate. In some cases a pollution threat may have been present for a long time, but the seriousness of the threat only belatedly recognised."*
>
> (Elsom, 1996)

In spite of past management successes over air quality issues such as emissions from industrial premises and residential smoke there is now a growing concern over air quality in many areas of the UK, particularly related to photochemical pollution in the form of tropospheric ozone resulting from the wide use of the private motor-car in densely populated areas (Longhurst, Lindley et al. 1996; Elsom 1996). In light of this problem there is a growing recognition that decision makers need to look for a new philosophy for air quality management (Longhurst, Lindley et al., 1996) aimed at moving away from the fragmented legislation of the 1990 Environmental Protection Act and the 1950's Clean Air Acts, towards a more "holistic health based approach" (DoE, 1997). This is the stated aim of the UK National Air Quality Strategy (UKNAQS).

The development of the UKNAQS has been described as *"a watershed in the history of measures to improve the quality of air in the United Kingdom"* (DoE, 1997). The act is stated as bringing together the concepts of sustainability and development planning established in the 1992 United Nations Conference on Sustainability and Development, and recent developments in the understanding of air pollutants and methods of tackling them. However, when one looks closely at the strategy and the accompanying 1995 Environment Act it may be seen that the development of the UK framework essentially brings together under one roof: the approaches first developed (and since independently developed by local authorities) under the 1956 Clean Air Act for local based management of air quality; the Air Quality section of the 1990 Environmental Protection Act, itself a direct descendent of the Alkali Acts; and developments within European legislation on emission and fuel technology. In this respect present policy development can be seen in terms of a cultural transition rather than transformation (Bate, 1994).

The dominant approach of the present UK air quality management framework is to use the tools of licensing (first issued under the Alkali Acts) and financial incentive and coercion to change behaviour (from the Clean Air Acts) and European derived technical reduction of motor-car emissions (Langston, 1990) in such a way as to attain what are essentially desirable end-states of generically set UK European ambient air quality standards. These standards are imposed on the local level authorities whose boundaries and remits have been set up over the last two centuries with the aim of regulating local sanitation and economic development (Cullingworth, 1982; Ratcliffe, 1992). These boundaries have been designed around historical settlement patterns (Smellie, 1969) and show no consideration to natural biophysical flows.

The co-ordination of local government approaches to development, economic and environmental health occurs through what is essentially a top-down management framework of legislation and policy guidance issued from central government (Smellie, 1969; McAuslan, 1980). This is reflected in the present management framework for tropospheric ozone and air quality in general, which is essentially that of a centrally stipulated set of aims and targets in the form of air quality standards, mixed with a great reliance at the national level on emission control technology that essentially enforces the fitting of the three way catalytic converter to modern vehicles.

The philosophy behind the approach of setting air quality standards can be seen as essentially end-state oriented. Policy approaches tend to be static, aimed at improving present environmental baselines to what are presently thought to be desirable set standards. The perspective for management concentrates on immediate localities defined by administrative boundaries.

However, unlike the industrial pollution of the past, road transport related pollution is not the result of a discrete source but rather is derived from the way our society has ordered itself, and can essentially be seen as a dynamic third world (Furguson, 1776) or emergent (Hadfield, 1997) phenomenon. Transportation patterns are implicitly linked to our way of life, the shape of our cities and the well-being of our economy as well as the sense of personal freedom and security we all enjoy.

Furthermore photochemical pollution such as tropospheric ozone does not impact in the same area as it is produced so much as in distant locations, often across different legislative boundaries, in areas that are often quite different in nature. Part 2 of this thesis illustrates the problems presented by these variations in the different aspects of the problem by breaking down the phenomenon into three subisystems:

1. a biophysical system, involving migration and synergy that changes over temporal and spatial scales;
2. a social system, involving the issues of production and reception along with the accompanying behaviour, personal values and need; and
3. a tiered management system that is fragmented both between and within these tiers, where the issue of air pollution as a whole is just one of many that are addressed on a day to day basis.

Table 8.1-1 Spatial and Temporal Variation in Tropospheric Ozone Management

O_3 Sub-system	spatial		temporal		
	local	regional	diurnal	seasonal	annual
Social (chapter 7)					
cultural/environmental background expectations	√	√			√
air quality as an issue	√	√		√	√
needs and desires for road transport	√			√	√
Biophysical (chapters 3 and 6)					
NO_x emissions	√	√	√	√	√
VOC emissions	√	√			√
Ozone production	√	√	√	√	√
Managerial (chapters 4 and 5)			**short term**	**medium term**	**long term**
power structures with local departments/interest groups	√			√	√
background Policy context	√	√	√	√	√
issue	√			√	√
resource base	√		√	√	√
commitment	√	√	√		√
relationship with other authorities	√	√		√	√
management options	√	√	√	√	√

Table 8.1-1 summarises the complexity of the overall social/biophysical phenomenon by illustrating the variation in each of these sub-systems which the management of the issue must account for. That these problems of scale and variation present many problems within the UK framework for air quality management can be seen in the

dropping of ozone standards from the list of legislated requirements for local authorities in the 1995 Environment Act.

Using the theoretical perspective of the environment as a co-evolving social and biophysical complex (discussed in chapter 2), this chapter reviews the present air quality framework with reference to its suitability for the management of tropospheric ozone within the United Kingdom in terms of the identified constraints that the biophysical and social systems involved in the origin, transportation, transformation and reception of this pollutant impose on its management, as well as the structure of the management systems themselves. It reviews the findings in Part 2 of this document and identifies the potential for a management and policy framework to affect its aims with respect to tropospheric ozone.

The chapter will use the interview data introduced in Chapter 4, to support salient points and findings, where relevant, by quotes from Bedford Borough Council officers taken from semi-structured interviews carried out by the author in 1996. The chapter concludes by highlighting the incongruity between management systems and the social and biophysical systems that they aspire to manage. In this respect the role of this chapter can be seen as identifying the nature of a strategic gap (Harrison, 1989) in the present air quality management framework in the UK.

8.1 Atmospheric Processes

From a biophysical perspective concerned with air flows, the problem of tropospheric ozone can be separated into two groups. The first is the propensity for the main precursor pollutants, i.e. VOCs and NOx, to gather in localised pockets, at particular periods of time (such as rush hours) to produce so called "pollution hot spots". The second is for these precursors to be transported very large distances and transform into tropospheric ozone via complex synergistic reactions which involve other factors such as climatic and chemical catalysts. Both of these issues are relevant to air quality management in many but not all regions of the United Kingdom.

In dealing with hot spots both the UK National Air Quality Strategy (UKNAQS) and the 1995 Environment Act can be seen as being what it claims, a watershed in air quality legislation (DoE, 1997).

The inducement to integrate transport, planning and health, concerns into a unifying framework is a significant step to allowing local authorities to merge issues and strategies across departments, set clear aims and therefore avoid policy clashes (Longhurst, 1996). However, there is a great question over the suitability of this framework for the management of the regional effects of air pollution and this view is born out by the fact that achieving ozone standards was removed from the 1995 Environment Act as being a legislative requirement for local authorities (Chapter 7).

Chapter 6 illustrated the possible regional relationships that are inherent to tropospheric ozone formation, and how many contributing factors may influence levels of short term and longer term concentrations of this pollutant. Here these factors are assessed in terms of the constraints they place on management strategies if one is to effect change in the exposure residents in a place such as Bedford have to this pollutant.

8.1.1 Monitoring and Managing Air Pollutants

The nature of the multi-scale ozone river indicates that the management of ground level ozone needs to be finely co-ordinated across regions that range from sub-national in nature to international if effective management is to be achieved. Furthermore when one is concerned with the management of a pollutant such as tropospheric ozone one is not merely concerned with an independent biophysical system but a system that is essentially the product of the emission and transportation of two very different substances, namely NOx and the VOCs.

The complex relationships between precursor concentration and the variation in spatial scale over which they may be derived, due to their different transportation rates, places a need for a finely tuned monitoring process (Huess and Wolffe, 1993), this point is noted in part 2 of the UKNAQS (DoE, 1997). This approach to monitoring is needed to allow for the analysis of concentrations of the precursors and ozone itself across a wide ranging dispersion pattern, to allow a management framework to identify which precursors need to be managed where and by how much. Any management plan aimed at reducing tropospheric ozone needs to recognise this complex interaction between the precursor pollutants. In the absence of this approach regional considerations may well be sacrificed within a fragmented monitoring approach designed around local air flows within the remit and agenda of different local authorities (Air Health Strategy, December, 1996). That this is indeed the case can be seen if one considers the very poor coverage with regards to VOC data within the London to Bedford region, where rural VOCs have been identified as a major contributing factor to the severity of ozone events (Possiel, 1991).

Although there is a general recognition in the 1995 Environment Act and the UKNAQS of the regional nature of air pollutants there is little in either of these documents to promote either a formal or informal, regional structure or strategy for monitoring. However, there are a series of what could be considered constraints to the development of such a regional framework.

The approach of the UKNAQS essentially ties the aims of local authority monitoring or assessment to localised problems. Within the context of tropospheric ozone this requirement is translated to an assessment of whether local areas will exceed standards set for NOx and the VOCs 1-3-butadiene and benzene independently. Monitoring is carried out by individual authorities or within small administratively based consortia. These are supported by legislative commitments that promote monitoring programmes whose design framework is centred around identifying hot-spot areas where single pollutants will be in excess of required air quality targets by the year 2005.

While it is recognised that the assessment is aimed at establishing the minimum course of action that local authorities are tied to under the 1995 act and the UKNAQS, there is also a great emphasis on promoting a least cost approach (Air Health Strategy, September, 1996). One of the factors promoting this approach is that funding from central government available to local authorities will be oriented around legal requirements, a feature noted in the following quote of Bedford Borough's chief environmental health officer (1996):

> *"the DoE has clearly stated that there won't be funding for anything which is not statutory"*

Any extra monitoring or assessment work carried out by local authorities may reflect the political will of that local authority to carry it out. This, varies greatly from one authority to another leading to inconsistency in monitoring in different areas affected by the same atmospheric flows (Hadfield 1994; Hadfield and Cannibal, 1996). The influence that this variation in political will may have on the availability of resources for air quality monitoring was commented upon by environmental health officers from Bedford Borough Council (1996):

> **(Interviewer)** *"The actual politicians, the elected members, do they have influence on how you would implement the 95 Environment Act?"*
>
> **(Chief Environmental Health Officer)** *"Very much so, because it would have resource implications. The politicians have a major stand on how things are organised in local governments."*
>
> **(Senior pollution control officer)** *"each authority will implement the Environment Act in a different way"*

Another problem resulting from the strong emphasis placed on the low-cost approach to monitoring and assessment affects central government monitoring. In order to facilitate local authority assessment in as low cost way as practicable, the aim of monitoring and modelling carried out by central government is intended to be primarily aimed at supplying local authority needs for assessing any required action within the framework of the UKNAQS. Again regional and central government policy is centred around identifying localised standards for individual pollutants in areas where air quality is not thought to be a problem (Air Health Strategy, November, 1996).

These locally centred approaches to monitoring are poorly designed to monitor the flows and relationships between ozone's precursors. This does little to provide an insight into the relationships between the causes and effects of tropospheric ozone and its precursors (Allen, Foley et al. 1993; Chang and Rudy 1993; Bower, Stevenson et al. 1994). The problems are heightened when one considers that the low cost diffusion tube monitoring carried out independently by local authorities is not compatible with that of the luminescence monitoring carried out by the NETCEN sites.

A final major constraint to regional monitoring of precursor flows and relationships for tropospheric ozone management can be found in the fact that a stated aim of the Environment Agency is to restrict it functions to those under the 1990 Environmental Protection Act and the 1993 Water Resources Act (Air Health Strategy March 1996; Air Health Strategy 1996a). In addition to this, an aim of central government is to leave decisions on how national monitoring is carried out to the jurisdiction of local authorities (National Society for Clean Air 28 July 1994; DoE 1995a; Air Health Strategy 1996f; NSCA 1996; DoE , 1997). It is apparent that the design or analysis of air quality monitoring at a regional or national level does not fall within the remit any particular organisation.

Overall the development of monitoring programmes is tied to a local perspective. This perspective is the basis of monitoring UK air quality and neglects consistant regional analysis. The consequence is that any regional analysis is confined to either expensive independent monitoring programmes or to the approach used in this thesis which is adapting locally designed air quality monitoring data to the analysis of possible regional multiple pollutant relationships on a best-guess basis. The latter approach lacks the resolution of data to allow for the finely co-ordinated managment of regional VOC and NOx needed for ozone management (Huess and Wolffe 1993).

In addition to problems concerning the regional monitoring of tropospheric ozone, one can see another similar set of constraints under the new framework, to managing the pollutant. The complex nature of ozone production and reception gives rise to a situation where there are many conflicting issues, facing many different bodies in different locations at different times within what can be viewed as one event.

That this is the case was demmonstrated in chapter 6 were, while it was seen that tropospheric ozone in Bedford is a definite health problem (Sweeny, October 1992; Sweeny, October 1994), there will be no legislative requirement to design a management plan with respect to this substance. However during the winter period there is a possibility that NO_2 levels may occasionally breach guidelines. NO_2 management strategies aimed at changing the use of the motor car in this area may in fact exaggerate the summer ozone concentrations while NO_2 reduction strategies in London may have little effect due to the VOC/NO_x ratio and background O_3 in this region. Reduction of O_3 precursors on the other hand may also have implications for the local population in London, both in terms of air quality due to a possible sharp rise in O_3 in that locality and restrictions on personal mobility. It is likely that the population in the capital will not perceive Bedford's air quality as a problem relevant to themselves.

However, an optimal management for London-derived tropospheric ozone in Bedford, aimed at reducing the magnitude of short term peaks, would require a VOC management strategy in the region covering London, not one to reduce the NOx. Thus the counterintuitive approach needed for ozone control at the distant location may well be in contradiction with local air quality problems. There is very little scope within the present management framework for individual local authorities in rural or semi-rural areas, such as Bedford, to influence air quality policy in large urban conurbations, such as London, who are faced with immediate local problems of their own. This is especially the case if management of one aspect of the system is needed to reduce problems at a distant location but results in little or negative gain in the locality responsible for it.

The situation leaves local authorities in both London and Befordshire caught between two levels. They recognise the need for regional, national, and international management of issues of air quality which are affected by factors which lie both geographically and institutionally beyond their control. Hwoever, they are also directly accountable to the residents in their districts, whose concerns and perceptions are more likely to be affected by what occurs in "their own back yard", and who expect local authorities to deliver acceptable air quality on this basis of their own expectations of overall quality of life. This point is illustrated by the comment from Bedford's Chief Environmental Health Officer (1996):

There is no solution locally for ozone. Reducing NOx and VOCs will have an adverse effect on ozone as we know because of the sink it is providing at the moment.

The strong local emphasis in guidance and legislation is counter to that needed for a regional perspective to the management of these pollutants. The paradox is complicated by the fact that a stated aim of publicising air quality data is to raise *local* air quality awareness in the locality to which the authority is answerable to (DoE, 1995; Air Health Strategy, July 1996; Air Health Strategy, December 1996; Air Health Strategy, December 1996; Air Health Strategy, November, 1996; DoE 1997).

8.2 Social Aspects

"It is argued that the policy makers in the past have ignored the role of local values, ethics and ideologies in the design of environmental policy: these factors can severely affect the policy outcomes and thus need to be integrated more fully in the policy making process"

(Vinod Ahuja: World Bank 1996)

While the current UK air quality policy can be seen as being based firmly within a context of existing tried and tested approaches and institutional structures, new problems of transport related air pollution and specifically tropospheric ozone can be regarded as an emergent outcome of how people have come to order themselves within their social and physical environment through the use of the private motor-car (Hadfield and Cannibal 1996; Hadfield 1997). Here it is argued that this essentially emergent feature of tropospheric ozone makes the problem poorly fitted to the present approaches to management.

8.2.1 The Need for Behavioural Change

In attempting to affect the underlying processes which give rise to transport related air pollution problems, the approaches found in the UKNAQS fall into two categories: Firstly promoting innovation and uptake of technology aimed at mitigating automobile emissions, e.g. through the introduction of legislation promoting the use of catalytic converters and low emission fuels; and secondly changing the behaviour of the public.

"... the aim of future planning policies must be to reduce the need for movement (instead of stimulating ever more mobility, as has for too long been the case). This will involve a gradual shift away from lifestyles which depend on high mobility and intensive use of cars".

(RCEP, 1994).

While the approach embodied in the UK National Air Quality Strategy relies on both of these aspects (DoE, 1997), at the central government level the role of behavioural change can be seen to be secondary to that of promoting a technological panacea. This is illustrated if one considers that central government's position is that *"improvements in vehicle technology are seen as the main contribution to improving air quality, in line with the principle of cost effectiveness"* (DoE 1997; see also Chapter 7.2 of this thesis).

However, there are documented problems with such a strong reliance on the technical fix approach, which has been widely criticised: Briefly these are:

- The tendency of new technologies, such as the catalytic converter, aimed at controlling one aspect of a complex system, to bring new and unanticipated emergent problems in their train (Sperling, 1984).This feature has been found to be applicable to the problem of tropospheric ozone since the selective reduction in NO_2 in vehicle exhaust has lead to policy which restricts future transport emission legislation to vehicles using this technology and may also produce urban tropospheric ozone problems (Nuttall, 1995).
- The development of policy based on a restricted set of technological developments such as increasingly sophisticated models of the catalytic converter, can block developments of other technological innovations that do not initially meet standards designed around the existing technology, but which may have the potential of producing better long-term outcomes, a feature that essentially restricts policy options (Sperling 1984; Viessman 1988)

This latter point is especially relevant if one considers that emerging evidence indicates the anticipated effect that the catalytic converter has on automobile emissions of NO_2 may have been overstated in the first place (Air Health Strategy, August, 1996; Air Health Strategy, April, 1996).

The main approach promoted by central government to changing the behaviour of the general public is stated as the development of "environment responsibilities" by fleet operators and by the public at large, mixed with financial incentives and disincentives to change behaviour. These include the introduction of an annual increase in road tax (5%) to place more of the real environmental cost onto the consumer and the promotion of greener motoring. Beyond this the act restricts its role in changing behaviour to the phrases "education of the public" and the need to "encourage debate in this area" (DoE, 1997).

However, the overall view noted in the strategy seems to be that technical emission controls will allow most areas to meet air quality standards by the year 2005, but there is a possibility that the projected growth in motor traffic may invalidate any potential benefits to be gained by reducing vehicle emissions (RCEP, 1994; QUARG, 1993; DoE, 1995). Therefore in order to combat intermediate localised hot-spot problems and to maintain these standards in the long term changes in the way people within modern UK society use the motor car must be brought about (DoE, 1997).

The promoted method of doing this in the UKNAQS is through new powers for local authorities to restrict or discourage private transport use by restrictions on parking space, the closure of roads to motorised traffic and encouraging long-term infrastructure changes in planning and transport policies to reduce both the need to travel and reliance on the motor-car (DoE, 1997; Longhurst, 1996). This problem is especially important in the context of ground level ozone in the south-central area of the United Kingdom. However, the general approach of promoting traffic management, mixed with central government financial incentives (or disincentives), coercion and education may have problems if one considers the nature of the problem they are trying to tackle. This point is shown in the quote from Bedford Borough's Tránsport Engineer,(1996).

> *However there is the big one, reduce private car use, this would require management of modal split. There is no hope of this within the context of central government policies. (.....) Or we can play games, traffic management just moves pollution around.*

In order for a strategy aimed at changing behaviour to be effective, the issue must be both understandable and relevant to the individuals whose behaviour is to be targeted (O'Riorden 1996). The strategy must appeal to the issues and values important in the recipient's life (Ahuja, 1996, O'Riordan 1996, North 1984). Consequently, one must consider strategies aimed at the reduction of tropospheric ozone in terms of the behaviour that causes the problem, i.e. driving.

At the national policy level there are two distinct approaches to influencing the behaviour of people to the use of the motor-car.

The first of these is the promotion of information available to the public on air quality (usually through local medium such as information phone lines and the internet, see section 7) so as to raise the general profile of air quality and to encourage the general public to change their behaviour in reaction to air quality issues as well as to allow the public to take measures to avoid exposure. This approach is described by the DoE:

> *An important part of the Government information service is provision of advice at different levels of pollution, and in particular, when air quality becomes 'poor' or 'very poor' according to the current system.*
> (DoE, 1995, Part Six: Monitoring and Public Information, p30)

However, in addition to the the problem of relating local air quality standards and monitoring to actual exposure, one must question the effectiveness of information strategies. This is important if one considers that research carried out on the public knowledge surrounding local air quality information suggests a low level of awareness of what is provided by local authorities (Hadfield 1994; Air Health Strategy July 1996; Hadfield, 1997), the reason for this may lie in the fact that the media used, tend to be active and inaccessible to the majority of the population at which it is aimed. Furthermore, when targeted populations are made aware of periods of poor air quality, most people, even those who belong to identified "at risk" groups, have been seen to respond poorly to advice informing them how to avoid exposure. However this is understandiable since there is little evdence that anty changes in behaviour will lead to any actual benefit (Schwela, D. 1996). This leads to the problem of using air quality information to effect a change in driver behaviour. A roll for this information that is described by the DoE as being significant (DoE, 1997).

In the management of transport related air pollution this is a problem, while people are willing to accept that air pollution is a concern this may often be of temporary concern (Hadfield and Cannibal, 1996). Furthermore, issues of air pollution do not exist in isolation, but are a part of an individual's perception of themselves within their social and physical environment. Studies have shown that while on a societal level people agree that there should be changes in driving behaviour to improve air quality, they do not translate this perception into individual priorities and action (Acury and Christianson, 1992).

An additional point is that the Air Quality Strategy points out that air pollution in the United Kingdom is only a perceived threat to sensitive groups (DoE, 1995), and not to the population as a whole. Therefore the majority of people who benefit from car ownership perceive that they are doing so at little or no cost to their health. To expect people to change their employment (if alternative employment could be found in many cases), the place they live, their way of life, or feelings of security (whether they be rational or not) for an improvement in air quality of their own free will seems hopelessly optimistic. Furthermore with the promotion, in the UKNAQS of the catalytic converter as a significant panacea to modern pollution problems (DoE, 1997), it is unlikely that air quality will be considered by present day motorists to be more of a threat to their well being in the future than it is at present.

Therefore when asking an individual to change their behaviour in order to achieve an improvement in air quality one needs to understand the importance of that behaviour to the individual. With respect to tropospheric ozone this behaviour is the use of the private motor-car.

8.2.2 The Car in Modern Society

The long period of cheap and accessible transport has facilitated living and working patterns that have formed the experiences and expectations of individuals and society as a whole in a mutually reinforcing way (Low, 1992). This is shown by dispersed patterns of occupation and the growth of leisure activities reflecting the willingness to commute (Wagener 1993).

The behaviour of driving is not a distinct activity but is tightly intertwined with people's working, social and leisure activities. While the growth in ownership and use of the motor-car has been tied in with the inexpensive costs in ownership and running, the last three decades of accessible transport has changed the way people regard transport, and the way in which they order their lives (Lowe, 1992).

The emphasis in the Environment Act and the UK National Air Quality Strategy on mechanisms to induce people to change their behaviour are essentially financial penalties on parking (at a local level), increases in vehicle tax and fuel duty (at the national level).

However, the results presented in Chapter 6 suggest that the cost of private transport compared to public has little to do with the individual's decision to use the motor vehicle and that features such as flexibility and accessibility are much more important. For example, the results presented in Chapter 7 show that in the south central Region of the UK, of the identified utilities that the respondents derived from car use, cost was rated of much lower importance than accessibility and flexibility, and was only on a par with the importance placed on comfort and security. Therefore if financial disincentives are to be successful these other needs have to be addressed. Otherwise financial disincentive may need to be so severe as to be coerce a large part of the population away from car-use, and are therefore politically risky to the governing body introducing them and miasmatic to the sense of well being within society as a whole. In this sense one can see that equity is an issue here that goes far deeper than merely as issue for liberal politics (O'Riordan, 1996)

In light of these findings it is easy to see why the government policy of a 5% annual increase in vehicle taxation and 3% increase in fuel duty has been shown to be inefficient in reducing car usage (National Society for Clean Air, July, 1994; Air Health Strategy, February, 1997), and is generally seen as a revenue raising device (Burke, 1997).

This feature is also complicated when one considers that the way people regard these utilities also shows variation along spatial and social dimensions. So for example in one area reducing the cost of public transport (or increasing the cost of private) may work better than in others and or for some parts of the population than others. However it may be less effective in places where access is of great importance compared to cost, or for groups of the population, such a females where security is far more important.

It can therefore be presumed that if the approach of imposing financial constraints is to be employed then disincentives in addition to those emanating from central government would need to be introduced by local authorities under the 1995 Act, along with the associated political risks. Research suggests that any revenue raised through transport management plans will be ill received by the public if it is not reinvested into transport infrastructure and improvement of alternative modes of travel (ENDS, 1996). The imposition of costs in the absence of provision of locally acceptable and significant alternatives will prove insufficient unless costs are imposed to a point that they exclude lower paid members of the community from the use of private transport, a situation which may prove politically dangerous to the continuance of the policy and which is against a stated principle in the air quality strategy which is allowing freedom of choice. Alternatives to car driving need to be supplied that recognise these expectations of the population if they are to be taken up by the public. This point was recently illustrated in Whitley Bay where an experiment of running cheap buses for seven weeks, by Tyne and Wear Council failed to win over any additional passengers in what is described as a very car dependent area (Air Health Strategy, January, 1997). Those that do not recognise these needs are likely to be ignored or resented (Ahuja, 1996; O'Riordan 1996), especially within a situation where air quality is promoted as generally good, and will only affect particular sectors of the community (DoE 1997). The problem of resentment within local population is potentially serious. This may arise from those who feel excluded from certain activities that have traditionally been taken for granted, or from local businesses that while paying large sums of money to local authorities in terms of business rates may regard local authority car restrictions as being very detrimental to their trade. This is illustrated by the following quote from Bedford's Borough Engineer (1996):

> *"Counties now have new powers to restrict peak area traffic. For instance in a case where there is high pollution levels - but this will result in them screwing up their town's economies - people would just go to Milton Keynes ...."*

An additional consideration is that by raising strong local concerns over mobility, a local authority may well have a detrimental effect over the importance people place on air quality as a comparative aspect of their social and physical environment, this is important when one considers that public concerns have been an important drive behind the establishment of air quality legislation.

A second major issue is that driving behaviour can be seen as an activity that is re-enforced every time someone uses their motor car (Hillman, 1992), in many cases this is on a daily basis. However, the implication of the fact that concern over air pollution can fade after the public have been exposed to the issue (Hadfield, 1997) means that to raise the issue of air pollution with respect to private, accessible and flexible transport means that the public should be kept aware of the problem i.e. the problem has to become relevant to them, as an individual in their everyday lives (Ahuja, 1996), in much the same way as the activity of car driving is. This implies that any public education program must be an on-going process of awareness raising rather than a one off publication of a booklet informing the public how to improve a car's environmental performance (DoE, 1996 chap. 6.64). There needs to be a concerted campaign to raise public awareness that is easily to accessible to all. To expect a population to make great efforts to discover an issue that is not considered relevant to their everyday concerns may be over-optimistic. The issue needs taking to the population.

8.3 Management issues.

The nature of tropospheric ozone generation from its precursors, as well as the behaviour causing the pollutant's emission, demands that management strategies not only need to address local pollution sources but must also be finely tuned across large and meso-scale regions. The problem therefore requires an approach that can draw in information from both the social and scientific disciplines in order to understand the processes involved in the issue and allow for the resolution of conflicting interests that often occurs within different administrative boundaries, while being applicable and acceptable to local cultural values and desires. Therefore the management strategy (or culture) needs to be able to integrate interests and knowledge from a variety of disciplines and occupations within any locality as well as between localities. It needs to recognise the needs of a particular locality as well as communicate these needs within a consistent and applicable regional framework. Furthermore management strategies need to be validated not only by the application of scientific knowledge but also within the response of the population whose behaviour and therefore values sets are affected by the management strategy. These needs can be identified in the concept of subsidiarity, integration and monitoring (see Figure 8.1).

This section of the thesis reviews the management framework described in Chapter 7 in light of the issues raised in the first two sections of this chapter and identifies the main constraints within both the implicit and explicit culture of the management framework.

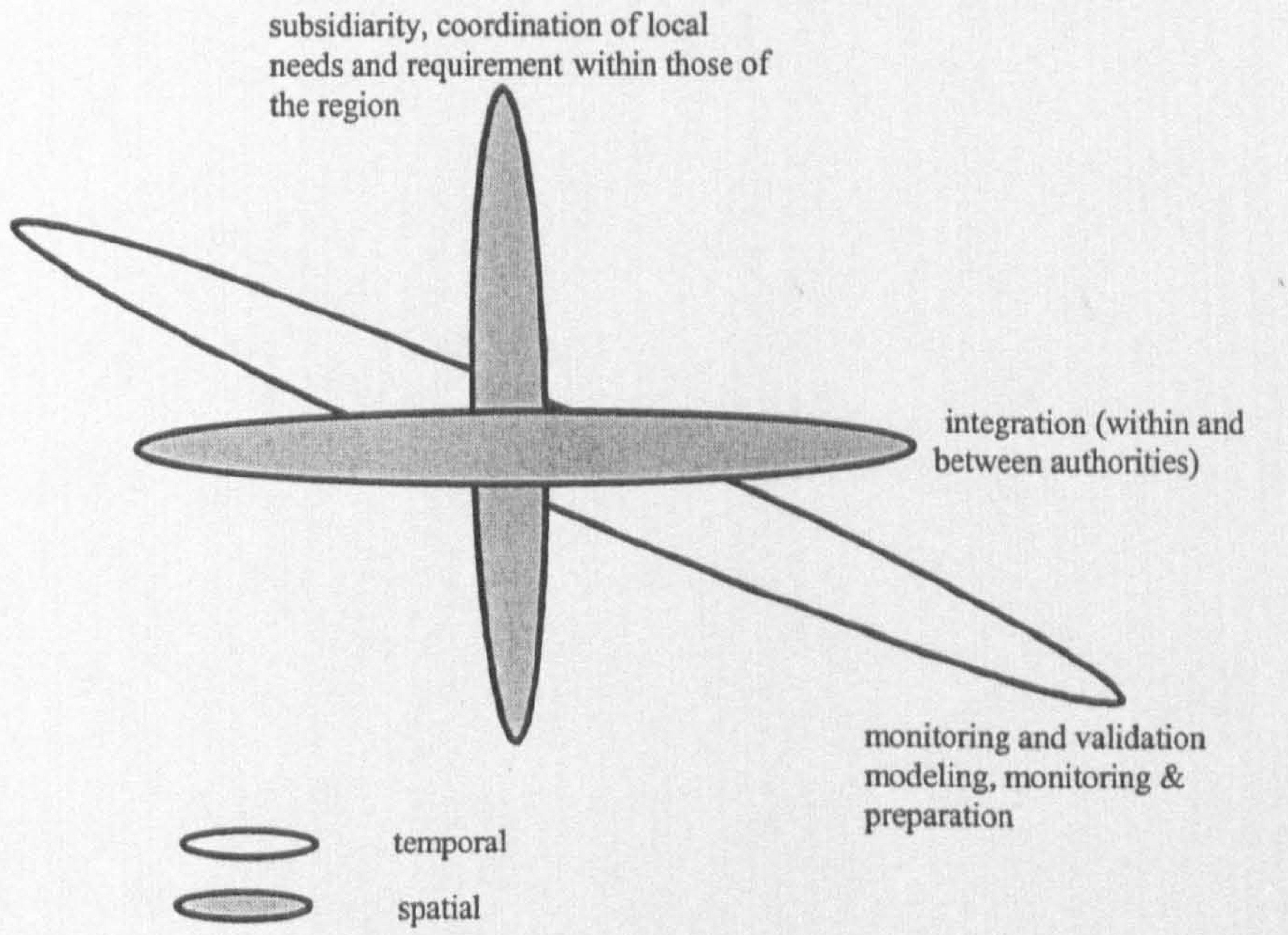


Figure 8.1: Conceptualisation of environmental management principles as a multi-scalar and temporal hierarchy.

8.3.1 Intra-Authority Integration.

The linking of transport derived air pollution to environmental health on a district-by-district basis in the form of local consortia, for the first time establishes the link between a local authority's planning and health functions. The granting of powers to local authorities to close roads, set up management schemes and set localised targets can also been seen as an important tool for improving communication and co-operation in the area of local environmental management as a whole (Longhurst, 1997), especially if these new powers can be used to produce positive results. This is implied by the following quote:

> *"meaningful outputs tend to produce co-operation. However insular behaviour alienates other groups. In Bedford we tend to have all the main departmental groups consolidated into one group and this can work, corporate working can lead to communication"*

(Bedford's Borough Engineer 1996)

However, the strong departmentalised structure within local authorities has established distinct approaches and value-sets surrounding the approach each group takes to a problem, essentially an occupational sub-culture (Bate 1994). This is shown if we look at Bedford Borough Council where, while a co-ordinated framework is being drawn up to approach the needs of integrating professional interests around the issue of air quality management, the following interview quotes illustrated that each of the departments involved essentially see their role of communicating their area of expertise and knowledge to a central process.

> *The way we're organised in the Borough Council is basically on specialist lines.*
>
> (Bedford's Chief Environmental Health Officer, 1996)

> *"There is a need to integrate Traffic Policy/highways planning and land-use planning."*
>
> (Borough Engineer, Bedford Borough Council, 1996)

> *I think our role is to primarily collect information, and to monitor the environment. I think decisions will be made upon the data we collect.*
>
> (Bedford's Senior Pollution Control Officer, 1996)

However, who or what is the central process seems less certain.

> *Job plan falls to the Director of Environmental Health and Housing,*
>
> (Borough Engineer, Bedford Borough Council, 1996)

> *"given that transportation policies and land use policies are going to bring more information to improving the environment. I think that the lead role, will be in those areas, not necessarily in ours. Traditionally, our role is to collect data."*
>
> (Bedford's Senior Pollution Control Officer, 1996)

In this respect one can see the approach that is evolving is essentially one which emphasises the individual functions of the respective departments concerned with management of air quality. In other words "what do we do and how do we apply it to air quality management?" rather than the approach of "how should we as a group manage air quality?". In this respect the approach resembles more closely the multi-disciplinary framework than the interdisciplinary one.

A final point to be made here is one raised by Bate (1996) and Mohr (1982). It is not only the explicit working relationships that can act as a constraint in the ability of each department to work communally, but also of individual working relationships (Bate, 1994) a feature raised by the Borough Engineer from Bedford Borough Council.

> *"groups consolidated into one group and this can work well. Co-operative working can lead to communication - but it is personality dependent."*

8.3.2 Inter-Authority Integration at the national Level.

The departmental structure of central government policy making in the UK has been described as being typified by the strong interplay of competing interests (Commission for the European Communities, 1993). Each department sets their own agenda within the overall acceptance of cabinet, but with a high degree of independence, albeit within a framework of growing dominance by the Treasury over the last twenty years promoting an agenda of tight controls over public spending (Burke, 1997, Jones, 1991). The policy emanating from this structure can be implemented directly from central government to the population in general, or can form directions for action to local government.

The segregation of each department operating within their own agenda has been described as a mechanism for managing conflicting concerns (Commission for the European Communities 1993), but it is also recognised that the older more established departments, as well as those whose interest are more in line with the philosophy of the ruling political party tend to dominate at the expense of others (Committee for the National Institute for the Environment Proposal 1994; Baily 1990; Axelrod 1994).

The effect this structure has had on the UKNAQS has been two-fold: Firstly strong objections to limits and targets by the Department of Transport and the Department of Trade and Industry severely delayed publication of the UKNAQS. This was eventually released as a white paper over a year late without official endorsement by the Department of Transport (Air Health Strategy Sept., 1996), with a reduced emphasis on the setting of VOC limits (Brown, 1996) and increase in the role played by the application of least cost over best practice (Air Health Strategy Sept., 1996). This has in turn raised the level of insecurity felt by the local authorities whose job it is to implement the strategy through the 1995 Act (Air Health Strategy, July 1996; Air Health Strategy, December 1996). The second feature of this approach is that guidance emanating from other government departments over issues of local development can often be in contradiction to the UKAQS, at least in the eyes of local authority officers who are meant to implement them. This is pointed out in the following statement from a local authority transport engineer:

> *"Context of our remit (concerning air quality management under the 1995 Act) is set within a range of policies, set by central government, for example PPG 12 & 13, these state for example settlement should be situated around transport corridors. However that leads to worsening air quality for residents along those corridors as traffic increase, and then there's privatisation of public transport.....Central government is inconsistent and this leads to a main issue of cynicism of central government at district level."*
>
> (Borough Engineer, Bedford Borough Council, 1996)

The problem of what a local authority would be allowed to do within this framework is of particular relevance when one considers the wide range of powers open to the Secretary of State to censure air quality management plans, even in designated AQMA's and the powers of the Secretary of State to decide funding of traffic management plans on the basis of the perceived merits of packages (DoE 1996, chap. 6 par. 53).

This can result in a situation where local polices aimed at improving air quality are constrained or contradicted by other central legislation passed down to local authorities, directly enacted by central government itself (Pas, 1986; Roberts and James, 1990; Hillman 1992; Air Health Strategy, November, 1996; Air Health Strategy, August 1996).

8.3.3 Inter-Authority Integration at the Local Level

Here we have similar problems within the present management framework as those identified above. However, here we have an extra distancing of occupational and locational parameters. A point illustrated in the following quote:

"When I was referring to the desegregation within a council, this is more so between."

(Borough Engineer, Bedford, 1996)

(interjects) *"The bottom line will be who is going to find the resource and how is it to be delivered."*

(Bedford Borough Planning Research Officer, 1996)

In addition to the needs of managing within their own disciplinary framework local authority officers also have to consider the requirements of their local population (section 8.2), both in terms of local transport, and the perceived and actual effects management has on the well-being of the local population within tight budgetary constraints. Points raised in the following comment.

"We're spending most of our time on complaints, even if the members wanted something they wouldn't be able to have it because if you go out and do some monitoring, or whatever, then you come back and there's a stack of complaints and angry people because you haven't responded.

(Hertsmere District Council Environmental Health Officer, 1995)

Furthermore, as in the case of the intra-disciplinary relationships, we can see a situation similar to that shown in intra authority communication where historical relationships may also constrain the willingness of different local authorities working together, if for example one authority sees another as a threat to their independence:

Luton do not historically get on with neighbouring districts, most of these small districts do not want to be a part of a bigger Luton.

(Borough Engineer, Bedford, 1996).

Or in assigning a co-ordinating role to another authority one may also find different degrees of commitment to that authority, as is illustrated by comparing the statements from Bedford Borough Engineer and that of Bedfordshire County Council's Greenspace Officer:

"Well I don't think that anyone has thought about regional strategies, If you did you would have to do that through SERPLAN the South East Regional Planning Group"

(Bedfordshire County Council Green Space Officer, 1996)

"SERPLAN is a joke it is appointed by government to a degree, to keep the lid on problems, not to deal with them"

(Borough Engineer, Bedford Borough Council, 1996)

Like the situation seen in intra-authority integration, explicit and implicit constraints, such as personal commitment and time, as well as past working practices of an authority can lead to great variation in the level of activity taken on in air quality assessment and management. For the management of a regional this feature can pose a problem, especially if local authorities are constrained in their ability to act by resource restrictions where each local authority has to self-prioritise what functions it carries out and what it doesn't. Figure 8.2[1] illustrates this point by showing the response from a number of environmental health officers from a range of different

[1] adapted from a series of one lines statement, each of which was assigned a score of 1 for each of the catagories mentioned

local authorities, when asked about the major constraint to carrying out air quality assessment. This point is pursued in the next sub-section.

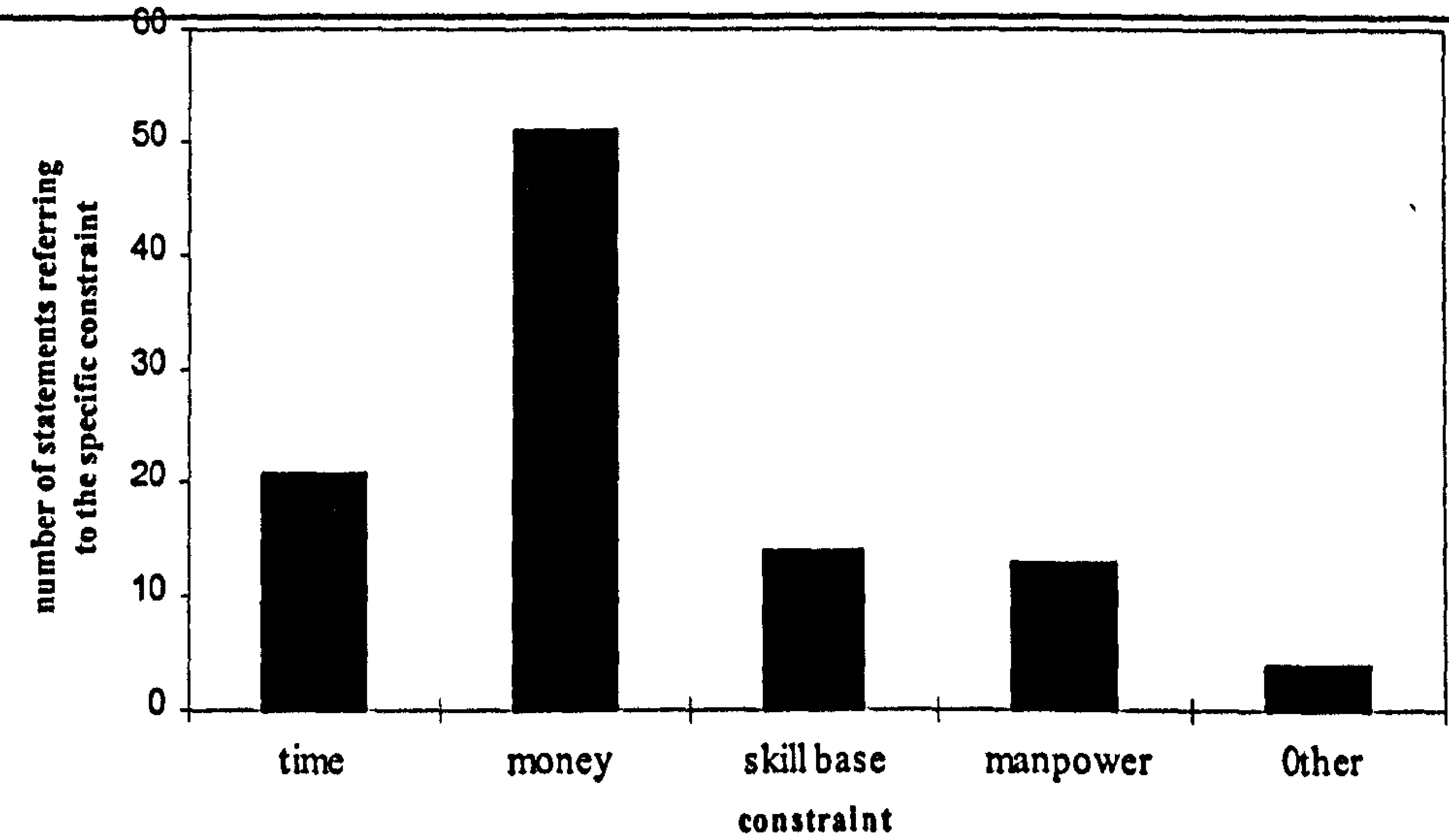


Figure 8.2: Constraints identified by a series of Environmental Health Departments with regards to carrying out a comprehensive air quality review (adapted from secondary data, 1995)[2]

The lack of assured funding is likely to deter local authorities from entering long term arrangements with other authorities or even with other departments within an authority especially when one considers the great emphasis on the least cost approach placed in the Air Quality Strategy (see DoE 1996, Chapters 3, 4, 6, and 7). The absence of a firm commitment from central government to adequately fund air quality management programs for all local authorities (district and council) and worries about committing resources to what may be an overly constrained process may impede any action from being taken. This point is demonstrated by the following quotes from district and county council officers:

> *"Central government is good at passing the buck - but not dealing with the causal problems. This leads to a certain cynicism on behalf of local authorities - they see that the policy will not work and therefore do the minimum to appease central government".*
>
> (Borough Engineer, Bedford Borough Council, 1996)

8.3.4 Coordination Between Tiers, Control or Subsidiarity.

A stated aim of the government's approach in air quality management is that of subsidiarity. Local authorities that are not regarded as having significant local problems are allowed to decide how they carry out air quality assessments and reviews (Air Health Strategy November 1996b). However, it has been pointed out that the concept of subsidiarity is not a created tool but the result of a pluralistic

[2] Hadfield (1994)

process where two or more strong interest groups with often conflicting interests, need to be resolved in a mutually satisfactory manner (Axelrod 1994), this is the situation which has existed between the European Commission and European Council (Chapter 3). The history and policy framework in UK air quality management show that such an equal power structure is not, nor has it been, apparent in the design and application of UK legislation.

The top-down and prescriptive approach in the present framework of air quality management shows this clearly. The setting of standards and the framework prescribed by the UKNAQS as well as the tight budgetary constraints are essentially imposed on local authorities, a point noted clearly in the following quote from Bedford's local authority engineer:

> *Central government more pushes its view on local due to the funding arrangements (local government gets about 70% of its funding from central government) and its non-consultation style. Presently the approach is to exercise financial and policy control over local government.*
>
> (Borough Engineer, Bedford Borough Council, 1996)

Local authorities have no role in prescribing air quality standards, which is the domain of the central governmental research body, the Expert Panel on Air quality Standards (DoE 1994; DoE, 1995a; DoE 1995b; DoE 1996), and have little say in the amount of funding made available other than none-official or binding representation through local authority associations. The culture in air quality management essentially reflects the UK policy framework in general, that is a top-down unicultural structure where aims, goals and approaches are imposed from central government and implemented at the local government level through legislation or heavily supported guidance. In addition some of the contradictions identified in central government policy are also handed down, which become apparent to those whose remit is to implement the policy (Parsons, 1996).

The approach shown in the UKNAQS essentially constrains local authorities to manage in accordance with what are perceived as the contradictory concerns of central government. Without a freedom to raise their own budgets (either from national or local sources) and confidently place management strategies with regard to their local needs and the needs of other authorities with which they are in negotiation, then the faith of local authorities in the intentions of the national government, and in their own ability to improve air quality may be severely constrained (Air Health Strategy, August 1996; Air Health Strategy, November, 1996). While much of the responsibility for achieving the aims of air quality management rests on the shoulders of the local authorities, there is very little they can do other than effect very localised change. The recognition of this fact may well be responsible for the dropping of ozone standards from the 1995 Act, as well as the growing guidance from central government towards local authorities to concentrate on very localised pollution hot-spots.

The essentially top-down structure within the UK air quality framework, while claiming to advance the concept of subsidiarity, rests in a management culture which is essentially top-down and prescriptive. It holds none of the mutual representation in drawing up policy goals, management approaches or funding provision that one finds between the European and National levels of decision making. The relationship between central and local government is based more on control than subsidiarity.

8.4 Summary

Overall the single pollutant approach with the stress on local management and least cost, typical of the policy development in air quality management in this century (Chapter 4) fails to define air quality management strategies that are needed to assess the biophysical system in terms of both an overall regional picture of both the causes and effects of the pollution. It effectively reduces a regional problem showing local variation to a series of poorly connected local problems.

This present framework may well restrict local authorities to an approach where what can be managed will be managed, which may therefore result in the development of air quality strategies that approach the local problems in ways that are quite unsuitable when viewed from a regional perspective. This represents a major constraint on any possible future development that may be taken on by local authorities with respect to the management of tropospheric ozone. In addition to this the budgetary constraints may well tie local authorities into carrying out air quality assessment and management in a prescribed fashion for which it can ensure funding. This will hamper innovative work into more regionally defined problems.

In addition to the problems arising from the biophysical nature of the pollutant, the sense of well-being that individuals, within modern UK society, derive from private car ownership is deeply embedded within societal values of freedom and accessibility. They are a product of, and formative characteristics of, modern culture and show qualitative and quantitative variation from place to place and through time.

Air quality management must recognise that any attempt to change driver behaviour should be acceptable and applicable to the population at which it is aimed (Ahuja 1996), in other words there must be a net perceived benefit to the public from changes in their behaviour on an individual level, for even in a situation where there is no net loss one may be faced with reluctance to change from a population used to certain patterns of behaviour (North 1984; Acury and Christianson 1992).

Approaches to changing behaviour need to be closely geared to the values and aspirations of the population at which they are aimed. Any restrictions that affect the feeling of well-being people derive from present day life-styles must be accompanied by compensation that is relevant and acceptable to the population that are subject to restrictions on their present day activities (O'Riordan, 1996). In the context of the management of transport related tropospheric ozone, this means ensuring that alternatives, supplied in the light of restrictions to private road transport, need to approach the needs of flexibility, accessibility, privacy and security people that derived from private car-use and that the importance placed on these needs reflects the cultural and spatial variations in the importance placed on them. Alternatives need to be closely linked to an understanding of the value set of a population at a very local level, an approach that, like those demanded by the nature of the pollutant requires a great degree of local flexibility within a tightly co-ordinated regional framework.

The present approach to the management of air quality can be divided into two main relationships. Firstly there is that between the European Union and its member states, where decisions are made through a pluralistic process of negotiation in order to reach agreement on aims, approaches and funding mechanisms used in achieving air quality standards and management. This approach is seen as essential in the UKAQS which states that the concept of subsidiarity is important and that it is used to allow *"each party to devise its own strategy for achieving reductions to which it is committed"*. It is noted that for this strategy to work *"there must be confidence in Parties' willingness and ability to meet the targets set"* (DoE, 1997). Within this concept it is stressed that each party needs to be able to implement strategies that best suit local cultures and climates. However, the relationship between central and local government is less participatory and essentially based on legislative and financial control over local authority goals and actions. This strong unicultural approach as been identified as allowing for little flexibility at the local level (Bate, 1994) and constraining in terms of allowing the growth of innovative approaches (Nonaka, 1988; Hassard and Sharifi, 1989). The strong control culture between these two groups is also apparent between both tiers of government and the general public in air quality management, the latter group being seen generally as passive receivers of policy and education programmes. When public representation is allowed for this is generally carried out through interest parties such as Local Agenda 21 groups. This approach poorly integrates the values and desires of the local population into the policy process.

The constraints presented by this top-down single pollutant approach to air quality management ties managers into dealing with localised problems of air quality that are amenable to local solutions, and is innapplicable in dealing with regional problems involving multiple interacting pollutants. The aspirations of air quality have been stated as the redution of episodes of summer smogs, where ozone is a strong componnt (Air Health Strategy, June, 1996). However the culture, when defined as the structure and strategy inherent in the managment framework (Bate, 1994) is not applicable in meeting these aspirations. This situation has arisen since the approach to air quality management still reflects those devised for managing domestic smoke or point source industrial emissions in localised areas. Therefore the supposition is that the evolution in air quality management areas has lagged behind changes in the biophysical and social systems causing the problems they wish to approach. From this we may conclude that there is a distinct strategic gap (Harrison, 1989), or cultural incongruity (Hassard and Sharifi, 1989) between the management, social and biophysical sub-systems that form the issues of high levels of tropospheric ozone.

9. A Framework for the Local and Regional Management of Tropospheric Ozone

This chapter presents a framework for air quality management, recognising the interdependence of the biophysical, social and decision making systems.

The approach aims to overcome the issues raised in the difficulty of identifying what are applicable and acceptable policy approaches for allowing the management of change in the biophysical and social phenomena that produce raised levels of tropospheric ozone.

While the framework concentrates on the issue of tropospheric ozone in the Bedford to London region, its aim is to form a generic conceptual approach for managing dispersed and behaviourally derived problems of environmental degradation in general.

> *I know no safe depostitory of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise thier control with a wholesome discretion, the remedy is not to take it from them, but to inform thier discretion by education.*
>
> (Thomas Jefferson 28/9/1820)

The approach to air quality management presented in this section accounts for the requirements of the present air quality framework, as well as the more implicit issues. These include: occupational separation with regard to values and agendas found within the tiered management process; variations in value sets and issues concerning the pollutant in question; the role that the behaviour causing the pollution has on the population, and the qualitative and quantitative variation in the biophysical process itself.

The framework, however, moves beyond the present requirements of air quality management with respect to tropospheric ozone to suggest a theoretically robust "best practice" approach which is relevant to the problem and the social and managerial context in which it rests (O'Riorden 1996).

The essential feature of the assessment and management framework is that it recognises the variation in issues surrounding the problem at different locations and spatial resolutions. It also aims to embody a proactive and evolving process that can mirror the dynamic nature of the issue.

While recognising the established structure within the tiered organisational framework involved in air quality management, the framework presented here also recognises that present management strategies within and between local authorities, although adequate to take on some of the management issues such as dealing with localised pollution hot-spots of precursors, are inadequate for dealing with others. To this end the framework will suggest changes in management strategies to allow a for a more collaborative and holistic approach to air quality management. The main features of the framework recognise the need for:

1. **An ability to account for localised problems of emission and reception including:**

- A need to understand the association between the pollution issue with respect to the individual in terms of concern and actual exposure in order to better understand the relevance of the issue to the individual.

- An assessment of the behaviour and activities causing the pollution and relating *with* the public over viable and acceptable alternatives to this activity. This aspect of the framework embodies the idea of legitimate public consultation, and moves away from the perspective of the public interest towards encouraging true participation. The approach includes: methods for raising the issue of air pollution among the population; methods for eliciting opinions from the *whole* population on the needs and desires that the activity supplies, a mutually co-operative process, between the members of the public and local authorities for identifying viable and acceptable alternatives to the activity and the scale over which these variations occur, in effect identifying the most suitable management level for action.

- A suggested management structure for introducing alternatives to the polluting actions, managing concerns of different professional interests involved in mitigative measures and air quality management, managing conflicting priorities to best suit identified alternative and mitigation measures.

- Monitoring of the uptake of measures and the effect that these have on the public behaviour and expectations, and on local air quality. This is essentially a recognition of the high degree of uncertainty surrounding the subject by recognising a need to validate that the effect of policy alternatives in the population affected are consistent with the goal of reducing polluting activity, and identifying as early as possible unexpected or unaccounted for emergent social and biophysical phenomena.

2. Suggested approaches for designing a framework for collaboration and co-operation for regionally derived pollutants incorporating an approach for:

- Regional modelling of the transported air pollution, including source pollution, the nature of any synergy between source pollutants, the nature of the pollution and levels received (chapter 5).

- A framework for regional, integration of information received from public participation exercises. Identify what behaviour produces what impact and where. What population benefits and which loses, as well as the nature of these costs and benefits. Identification and negotiation of compensation. Methods for designing and implementing regional strategies to reduce polluting activity.

- A management framework for collaborative monitoring, management, and negotiation between different authorities. Possible mediators, and sources of information.

The framework offered here is fundamentally different from that offered in the UK National Air Quality Strategy (DoE, 1997) in that it stresses the importance of information flows between professionals involved in air quality management at both an explicit and implicit level. It also stresses the requirement that information concerning aims, constraints, and enablements needs to be communicated in both directions between each tier of the managment framework . In addition it to these, management issues the framework also stresses the need for a two way flow of information between those who design and implement policy and those whose behaviour and attitudes the policy is aimed at affecting (see figure 9.1).

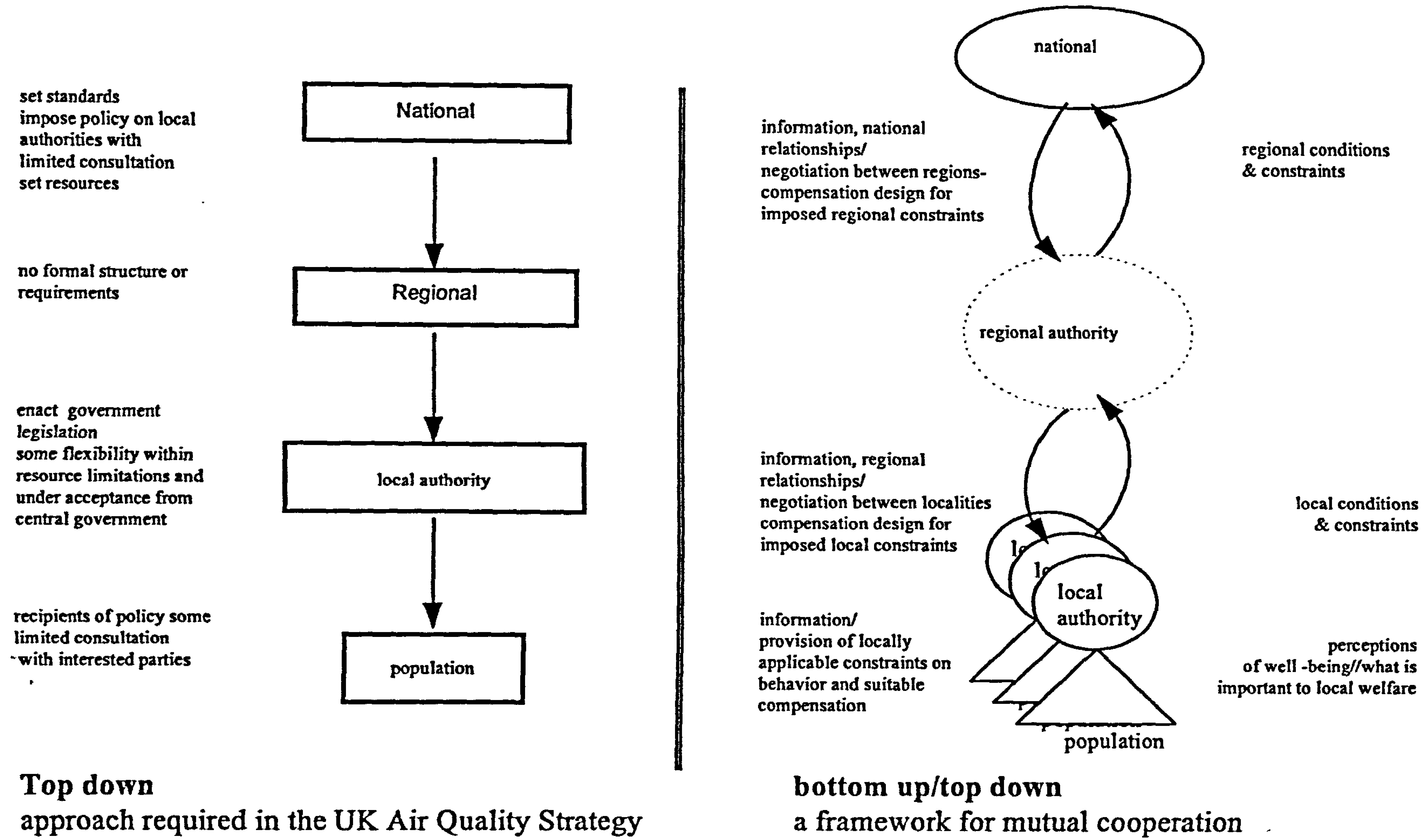


Figure 9.1: A comparison of information flows in decision making between that of the present air quality management framework and the framework proposed in this thesis

9.1 Designing an Issue Lead Strategy: Understanding the Problem

One of the main features of the framework is to identify the nature of the biophysical flows with which local management is actually dealing. Within the issue (or environmental problem) led approach this is the driving force behind building an integrated framework. The first step is an holistic assessment of the problem in terms of is biophysical and social features (chapter 2).

The data requirements highlighted in the following sections concentrate on the more non-standards proposals to air quality management. Standard approaches to monitoring urban monitoring and transport management are outlined in chapters 5 and 6.

9.1.1 Problem Assessment: The scoping exercise.

The role of this process within an integrated framework moves away from the most cost-effective identification of local pollution hot-spots with respect to air quality standards, which tends to dominate the philosophy behind present air quality management systems. Instead it offers one that is organised around aspects of the system (see: chapters 6 and 7) driven by a theoretical understanding of the system as a biophysical and social complex (see Chapters 1 and 2).

The present question in air quality monitoring tends to be one of how this should be done within aims set by central government (i.e. the monitoring of air quality at very specific locations with regards to established standards) rather than why it is to be done (for example see Air Health Strategy, October, 1996; Air Health Strategy September, 1996; Air Health Strategy November, 1996;)

However, in light of issues raised in the previous chapter concerning the variable and regional nature of the systems involved, it is apparent that as well as identifying areas of strong local concern, monitoring programmes need to take on the more strategic aspects of the problem being faced by localities with respect to air pollution. These can be summarised as:

- Issues arising from biophysical flows, identifying the nature of the biophysical system involved in the pollution incident of concern. The spatial and temporal variations within the biophysical, and the relationship between the cause and effects. In the case of tropospheric ozone in Bedford this translates into understanding the relationship that local ozone pollution has with London derived precursors and the effect that this meso-scale flow has on the larger scale European flows as well as the relative roles that more local sources of NOx & VOC may have on the production or suppression of the pollutants.

- Issues arising from the social systems as an aim to identify the role which the behaviour causing the pollution, has in society and how the biophysical system effects the population, and how values and attitudes related to both of these features vary from location to location and with respect to cultural parameters within the boundaries defined by the biophysical flows.

  With respect to tropospheric ozone this equates with the reasons why people use the motor-car and how they perceive the high levels of air pollution affect their quality of life. The role that the car has in their well being must be understood if alternatives are to be supplied that are both applicable and acceptable. The relative merits people place on clean air compared with the actions they undertake that contribute to the pollution needs to be known and monitored. If the issue of air pollution is to be used to influence transport mode it needs to be made as important an issue to the driving population (either singularly or in combination with other issues such as accident risk) as are the benefits that the population gain from the use of the motor-car in their everyday lives.

- Management Issues, the assessment of the problem also needs to identify which groups in what locations have a role in the management of the social and biophysical aspects of the pollution phenomenon. Its aim is to identify the professional expertise and remit that is needed in executing an effective strategy to manage the incident at the local and regional levels over which the pollution event occurs.

Within an interdisciplinary framework such an assessment or "scoping exercise" (Baily, 1990; Cannibal, 1993; Therivel, 1994), is the main driver to the definition of the management strategy. It selects the range, and participants of the exercise as well as providing a starting point for the framework's activities.

9.2 Assessing and Monitoring the Biophysical System

Chapter 5 illustrates the regional nature and some of the complex relationships between regional and local issues related to the production and reception of high levels of tropospheric ozone. It concludes by pointing out the need for a co-ordinated monitoring strategy that can identify local issues and concerns and communicate these in a regional context. This section of the thesis presents an approach for carrying out these two aspects of a monitoring programme. A co-ordination and management framework is presented in section 9.4.3.

9.2.1 A collaborative framework for monitoring tropospheric ozone and related precursors.

The first stage of constructing a regional and local monitoring programme is to assess the needs and air pollution related problems of the regions involved (Figure 9.2).

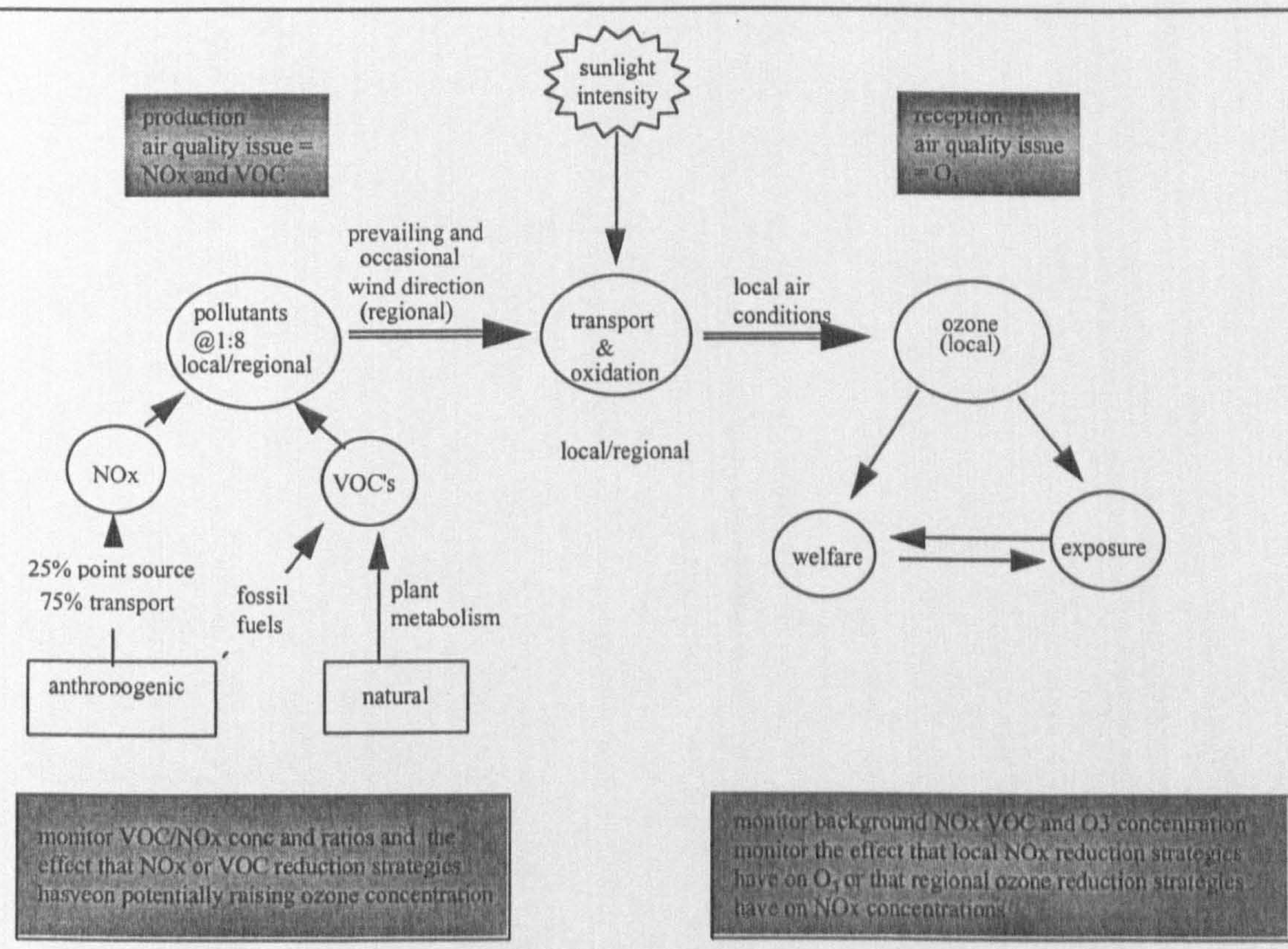
Similar studies have been carried out in the United States and Canada for air quality managment bodies (Wolf and Lioy, 1980; Huess and Wolffe, 1993; McKendry, 1993; Chameides, 1994), through a co-sponsored research programme run by academic institutions, to draw on specific expertise to design and implement theoretically designed programmes Such an approach that been useful in other strategic management issues (Leavitt, Dunbar et al. 1996) and involves the modelling of the source and distribution of air pollutants and their precursors.

Regional monitoring information, when used in conjunction with local monitoring exercises such as those suggested in section 6.1, can help identify climatic conditions, air pollution rivers, and areas that are the sources and recipients of air pollution. This information can then be used to allow authorities in the area to locate a more concise monitoring framework suitable to the problem being tackled in the most cost effective way.

The monitoring strategy, once established must be agreed upon with regard to its aims and the form that monitoring equipment and data collection, storage and analysis is to take. This could take the form of a co-operatively produced manual for the region taking into account the following features (Neighbour 1996):

- formats used in other regional programmes
- recommendations for data handling, storage and compatibility of any analytical software used.
- a list of local authority expertise and equipment within a region to enable exchange
- a list of expertise in the form of academic institutions and/or consultants

For the problem of tropospheric ozone one must avoid taking the single pollutant approach, monitoring should not just reflect the needs of the local population in different localities but be designed to allow the in-depth study of the relationship and interaction between synergistic pollutants under a range of meteorological and climatic conditions (a point covered in chapter 6).



A regional monitoring strategy aimed at facilitating ozone management requires monitoring of NOx and VOC's in identified source areas, Ozone and VOCs (including naturally derived VOC's in reception and intermediate areas. However in addition to this the effect of reduction strategies (both local & region, NOx or ozone) on the system must be closely monitored to avoid surprise and unintended consequences such as worsening of overall air quality due to increasing ozone levels caused by NOx local reduction strategies

Figure 9-1: Ozone production system and monitoring requirements

It is strongly suggested that the distribution of the flows that form the natural atmospheric system (identified in any modelling exercise) should be the driving force behind the shape and size of the monitoring region, rather than established political or administrative working practice, although, it is recognised that this is often impractical due to political and/or financial considerations and that compromises may need to be made. It should be noted however that once relationships between components of this system are recognised, one pollutant may have the potential to act as an indicator for others and therefore reduce the demands put on monitoring resources. In the present background of uncertain and limited resources for air pollution monitoring, scoping studies such as the one described here can represent a great saving for local authorities. Monitoring data gained from such a process can then be fed back into the original study and a sophisticated picture of the nature of regional air flows may become possible for the first time.

It does need to be remembered however, that the success of any monitoring programme depends on the level of commitment and co-operation between different groups within the region under study (see section 9.4.3.).

9.2.2 A Method for the Identification Monitoring and Management of Personal Exposure To Transport Derived Pollution Hot-spots In Bedford.

In addition to the regional programmes, the management strategy also needs to be able to identify and communicate the relevance of local air pollution issues to the population subjected to them. Therefore a monitoring framework that can assess the relevance of pollution levels to the population also needs to form a part of the overall framework.

One aspect of transport derived air pollutants is that they may accumulate in very localised areas such as kerb-sides by congested roads and along narrow, high sided streets that are subject to heavy traffic, to form areas of raised pollution levels, or hot-spots (Elsom, 1992). The location and strength of these hot-spots can significantly influence the impact on human health from air pollution in a given location. However, these locations are not necessary equate with where the pollution is emitted, or where there are people to be exposed. The quantification of personal exposure to ambient NOx and VOC levels in respect to road transport is needed in order to identify and communicate the importance of these substances to the health and well-being of the individual with respect to best available toxicological and epidemiological evidence. This information is needed if the individual is expected to change their behaviour based on these concerns.

Therefore as a part of an approach for monitoring local air quality the following monitoring approaches designed to identify and monitor exposure to transport derived pollution hot-spots is put forwards as a first stage in developing such an approach.

9.2.2.1 An example of a transport derived pollution to exposure model developed for Bedford Borough Council.

The framework presented here was developed from a research project to design a preliminary method for forecasting the occurrence of hot-spots within the Borough of Bedford (Hansen, 1996), and to assess the importance of these areas in terms of population exposure (see UK Air Quality Strategy, chapter 3 para. 22). To this end the model represents an integration of data and working practices of transport engineers and environmental health officers. It is proposed that design of this model would be a collaborative effort from both these groups. Readers requiring a detailed commentary on the structure, design and data requirements of the model are directed to: Hansen,.

L.P.H. (1996) *Modelling Exposure to traffic derived air Pollution.* (MSc. thesis) Cranfield University

The model used is a two part spreadsheet model (see Figure 9.3). The first part of the model is a module for forecasting derived pollution from transport at specific locations. This was derived from existing techniques for forecasting and modelling urban pollution. Data used in this module are: traffic volume and flow, a conversion factor (to account for modal split, fleet age etc.) and a dispersion part that which gives an indication of the final concentration at the desired location.

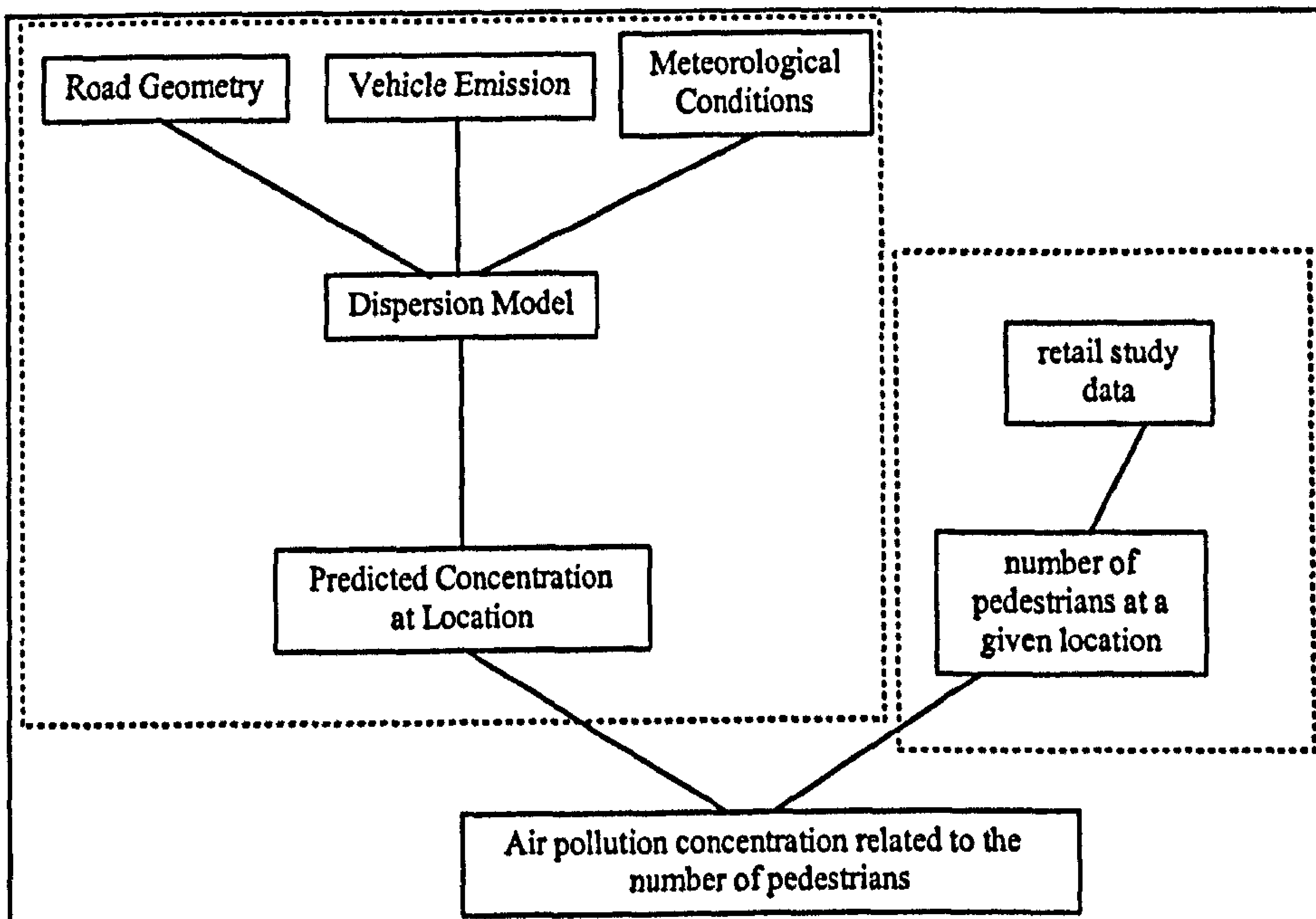


Figure 9-2 Model components for a local pollution exposure investigation (after Hansen, 1996)

The second part of the model was a module for forecasting the movement and concentrations of pedestrians. Techniques used in this part of the model were not found to exist, and data from other sources were used. In the case of this study useful data was to be found in a retail study of the town centre that supplied information on pedestrian volumes in given locations of the town centre at particular times of the day (It was noted that further data on exposure period, i.e. length of time individuals spend in the area, would improve the forecasts). Although specific to the town centre of Bedford the model would also be suitable for generic use by substituting this data with appropriate local retail studies or desegregating data from the national census. The output from these modules is then integrated to produce a pollution exposure forecast.

The model was applied to two locations in Bedford and successfully identified one of these as a hot-spot due to the coincidence of high pollution levels and high population exposure. The approach was a fairly simple spreadsheet modelling exercise requiring limited expertise to set up and with low data requirements compared to many of the operational urban models. Yet it proved to be a valuable tool in identifying areas of potential hot-spots, allowing for a more targeted and therefore cost effective approach to urban pollution monitoring than those used at present, and drawing the attention of land-use and transport planners to areas of most concern. It should be noted at this point that any action to reduce hot-spots such as road closures or diversions should be carefully planned so as not to induce displacement of high pollution concentrations (as a result for example of congestion) to other areas of high population, but using this approach traffic management that can move areas of heavy pollution to those occupied by as few residents as possible. However caution must be taken as to the sensitivity of any new recipients both in practical health terms and perceptions since, as areas show variation even at the local level in their background pollution, so do populations in their tolerance to pollution (Ashby and Anderson, 1981; Hadfield, 1997).

9.3 Social Issues: Public Participation and Local Perception Management.

There are two main aspects of concern to this part of the investigation: the analysis of how the public perceive the problem of air pollution in their everyday lives and the role of the behaviour causing the problem. It should be remembered that both of these show spatial and temporal variation (Hadfield and Cannibal, 1996; Hadfield, 1997).

Within the UKNAQS much emphasis is placed on encouraging the public to change their transport behaviour away from one so reliant on the motor car, (for example by introducing park and ride schemes, increasing the cost of parking, or encouraging the public to use alternatives such as cycling or walking). However programmes such as these are often seen as unsuccessful and are poorly taken up (Air Health Strategy August 1996, Air Health Strategy August, 1996; Air Health Strategy, November, 1996; Air Health Strategy January 1997). These management schemes can often represent significant investment in both time and money.

9.3.1 Investigating public needs and wishes

It was illustrated in chapter 5 that the presently proposed public participation programmes have are essentially restricted to consulting with stake-holders or public interest groups or education programmes aimed at changing the values and actions for the general public with respect to car-usage or driving habits. In this latter case education programmes are essentially a top-down attempt to control the actions of the population within aims set at central or local government. The approach suggested here, however, is a two way process of informing both the public and the policy makers to the social nature of the problem at spatially relevant resolution.

It was illustrated in chapter 7, that one of the main reasons why financial disincentives have failed to curtail growth in private road traffic is that the emphasis placed on purely economic costs by the policy making organisations is not reflected by the population at which these policies are aimed . This reflects one aspect of a much wider problem that has been identified in environmental management concerning how the priorities, issues and values of the population are considered in the design of policy tools and mechanisms. It has been shown that these value sets substantially affect the outcomes of policy and the life-span of strategies (Ahuja, 1996; North, 1984)

9.3.1.1 Rationale

Within a society that has an inequitable wealth distribution it may be suspected that if economic disincentives are used to prohibit vehicle use there may be a great incentive for individuals to reduce costs in ways that fall out of the general agreement of society's rules (Ahuja, 1996). This may be expressed as political disfavour, public pressure to reduce the value placed on the environment or, at the extremes, to illegitimate action ranging from vehicle tax avoidance and illegal parking to a rise in property crime (North, 1984). The worst case scenario may be a society where opportunities and ultimately feeling of membership may be divided between those who have access to transport and those who do not (Lemon and Naeem, 1990).

Concerns over the environmental impact of transport on local air quality have been shown to vary with respect to geographical location (Chapter 3, see also Hadfield and Cannibal, 1996; Cannibal and Hadfield, 1997). Research presented in chapter 6 of this thesis also shows this is the case for the sense of well-being people receive from ownership and usage of the private motor vehicle. It is therefore suggested that elicitation and monitoring of these opinions be carried out by local authorities or their representatives since this management tier is one that has the closest resolution to the local scale over which this variation occurs.

The aim of the exercise is to elicit opinions concerning the qualitative nature that the ownership of a motor vehicle plays in the general quality of a driver's life and compare these with the importance that each individual places on what can be seen as negative features resulting from the use of the motor-car. This is needed to reduce the problem apparent in present environmental attitude studies, where the individual may agree in principle that car use needs reducing but this opinion is not translated into behaviour (Hutton and Ahtola, 1991; Acury and Christianson, 1992). The approach presented here aims to supply viable and acceptable alternatives to that behaviour (chapter 6). In order to supply alternative options that constitute an overall gain for the individual.

9.3.1.2 Data collection and requirements

The research should be carried out with the aim of eliciting opinion from as wide a range and representative a group of the public as possible. The present practice of eliciting from the most accessible groups in society, such as pressure groups, and environmental organisations such as local agenda 21 groups, should be resisted, since by their nature these groups are not representative of the majority of the population who do not belong to them.

Suggested techniques for gathering information oconcerning needs and wishes that the motor-car provide are:

- door to door interviewing
- on street interviewing
- telephone cold calling
- postal questionnaires

Useful and informative data can be gathered from the use of a brief, structured questionnaire, similar to that used in this thesis (see Chapter 7).

Techniques for eliciting and comparing these needs with the importance of the issue of air pollution and environmentally less damaging alternatives to the motor car do pose somewhat more of a problem. While people often express the view that they would change their behaviour to improve environmental quality, this in actuality is seldom the case (Arcury and Christianson, 1992). However, there are a series of techniques for eliciting implicit opinions such as the revealed preference techniques .

Any alternatives put in place to discourage the use of the motor car must take the results of such an exercise into account. In this way such an exercise may save much time and money in improving the utilisation and success of these alternatives. However such a research activity does need following up after an alternative is in place to monitor whether effective utilisation is taking place and establish reasons in the event that alternatives are not used.

9.3.2 Public Education Programs

As stated earlier the exercise of public consultation should be seen as a two way process. The previous section concentrated on how this process is of value in educating the policy maker. However it is obviously important to educate the public as to the how the issue at stake can affect them and how their activities affect the issue. Essentially the joint process is one of moving the values of the public and policy making body closer together.

9.3.2.1 Rationale

In air pollution management, the importance of this process is in raising the issue on the public agenda and giving the public the confidence that activities they adopt will have a beneficial impact on air quality. This view was expressed by a local authority environmental health officer:

> *"People have to care in order to change their behaviour. Public legislation crossover seem to be neglected by the act."*
>
> (Bedford Borough's Chief Environmental Health Officer, 1996)

as well as a district authority engineer:

> *"We need to convince the public that we are acting on their best behalf - communication and involvement."*
>
> (Borough Engineer, Bedford Borough Council, 1996)

Raising the issue can also be an important element in strengthening standards and ensuring action from parties beyond the local authorities' control (such as central government) since it is accepted that much air quality policy has been brought about by concerted public pressure (Longhurst, 1996; Ashby and Anderson, 1981).

A local information strategy like any alternatives introduced should first be researched to test its suitability to the public who are intended to be the target. Here it is suggested that the information should be targeted in a similar way to an advertising campaign, for indeed the role of such a programme is to advertise environmental concerns. Merely making information available is no surety that anyone will take the time and effort to find and read it. The choice of media is vitally important.

9.3.2.2 Methods for public education programmes

Approaches to informing the public and raising the issue are as follows:

- information on a day to day basis on air quality, pollutants affecting air quality and possible health effects of these pollutants to health of any group in the population.

- general education into the nature, sources, health effects and the impact on the urban environment from air pollution
- specific promotional campaigns to highlight the long term health effects that air pollution can have on sensitive groups such as children
- alert warnings during periods of high pollution
- information on location and duration of hot-spots
- promotion of alternatives to road transport use
- information on how motorists can reduce the impacts of their activity on the environment.

Media should be as accessible as to the individual as possible regardless of the importance that individual places on the issue of air quality. It is suggested that media such as the television (i.e. local channel public information broadcasts) and local newspapers that are received directly into the home, seem to fit this remit most closely and those involved in communicating air quality issues to the public may well benefit from referring to the marketing literature (Air Health Strategy August 1996 1996a).

9.3.3 Summary: Public Participation as a Two Way Cultural Process

The overall aim of this approaches to public participation is to allow the wants and needs of the general public and those of air quality managers to communicate in such a way that both groups work more closely to the same goal. The role is effectively to encourage convergence between the social perception and values surrounding the issues and those directly involved in its management at a local level.

The process through which this is achieved can be summarised as building a dialogue accounting for public needs and wishes while at the same time raising the profile of the issue. In addition to raising the profile of the this process may encourage the belief that any action to public do take may result in benefits to their personal physical and social environment. This may then encourage more concern in this area, which has been shown to promote the acceptance of tighter standards overall leading a self perpetuating process of public self regulation (McAuslan, 1980).

9.4 Adapting Management Practices to the Issue: Resolving the Strategic Gap

The following suggestions aim to illustrate a management framework that needed to build a co-ordinated and integrated framework of local and regional air quality management. The approach aims to resolve the issues identified in chapter 8, and is essentially based on the pretext that one needs to move from the highly constrained top-down uniculture in air quality management in the UK to a more pluricultural and flexible approach (Baily, 1990; Bates, 1994). The aim of the framework is to allow a close grass roots analysis of local variation to be incorporated in a regional framework as a method for allowing a management framework the opportunity to approach real life situations in a more responsive and innovative way (Nonaka, 1988). The approach moves away from the management issues facing different tiers in the framework being described in terms of local or regional issues to one which describes them in terms of local and regional issues (Bates, 1994) and moves from a remit led approach to one of mutual co-operation (Hardin 1968).

9.4.1 Co-operative management within each tier: Integration

There is a recognised need for closer co-operation between the different professions and disciplines involved in the issues of environmental degradation. This is especially so in the case of transport derived air quality and is a sentiment echoed in the following quote:

> *"The key features* [of designing an air quality management plan] *will be an interdisciplinary approach, because we're not the only key player in this"*
>
> (Bedford's Chief Environmental Health officer, 1996)

Participants in this process will need to come from a wide range of professions and suggested participants include:

Local Authority Engineers	(transport planning and strategy functions)
Local Authority Planners	(land-use and economic development)
Environmental Health Officers	(monitoring and health issues, possible strategic role and representation of public interest)
Finance Officers	(funding)
Education Officers	(public awareness campaigns)
Local Public Transport companies	(provision of public transportation)
Academic institutions and/or consultants	expert and state of the art knowledge on air pollution and social systems
Local Health Authority	(linkages with air pollution and respiratory problems)
Local Chamber of Commerce	(commercial interests)

Each of these interests and professions brings with them expertise and each represents a valuable knowledge base for managing different aspects of activities related to air quality. However, they also bring with them personal and occupational issues, preconceptions and values. It is necessary to establish a framework within which the professional groups can co-operate to unify aims and set these aims to convergent goals within a unified strategy.

One of the main problems facing organisation is one of unifying the often highly divergent cultures (i.e. the things that the do and the why and how they do them, see chapter 2) of different groups. An identified method of doing so is in promoting the communication between these groups in order to promote consensus, or in the absence of a possible consensus, to allow for the management of conflict to a level where compromises are at least satisfactory to all (Bates 1994). Without this process of dialogue building different groups may well act towards different goals (either stated or non-stated) resulting in strategic plans failing or running into inertia (Harrison 1989).

The proposed framework for managing air quality has as its main aim the purpose of fostering this communication and adapting present approaches to local authority decision making to allow for a more integrative and unified approach (Jarillo, 1994).

However, interdepartmental communication can be difficult (Jarillo, 1994) as is shown by the following quote from Bedford Borough's Transport Engineer (1996):

> *"but integration within an area i.e. getting colleagues to work within a local authority, across disciplinary and cultural divides can be difficult."*

This quote also identifies a major problem, that of cultural attitudes, which can be reflected in language assumptions and personalities as is shown when the engineer continues his dialogue:

> *"this can be partly due to organisational reasons or partly personality"*

Personalities and associated personal values, motivations and insecurities are often identified as important features when identifying why integration within a department fails and studies suggest that communication, working together and simply getting to know each other in a working environment can be important aspects in over-coming these problems (Bate, 1994; Nonanka, 1988), especially if one has a mutual and achievable goal to work towards (Ackoff, 1970; Bates 1994; Ahuja, 1996). The aim of this process is to change the general culture of local authority working from one that is departmental oriented to one which is centred around co-operative round table working groups.

The framework shown in Figure 9.4 is an example of a such a structure for integrating professional interests for the management of tropospheric ozone and its precursors. The framework shows the makeup of a working group within a local authority and an example of how this would relate to agencies outside the local authority structure (in this case the general public and local health authority) and the two way social investigation described earlier.

The working group (in grey) would be best formed from senior members of each department or deputies who have the confidence of total support from their heads (Bates; 1994). The reason for this is two fold: firstly it is this group that have the flexibility to both enable or constrain the role the department plays in the process, and secondly the most senior members of departments are usually those used to working within the departmental culture that the process is aiming to change, and therefore may benefit the most from this process of change and be in the best position to communicate new working practices to their subordinates.

Within this figure the suggestion is made that the local environmental health department would form the gateway between the issues and perceptions of the local population and that of the development team. This role would be suited to the existing strong links between this department and the public and the present expertise this department represents on air pollution issues.

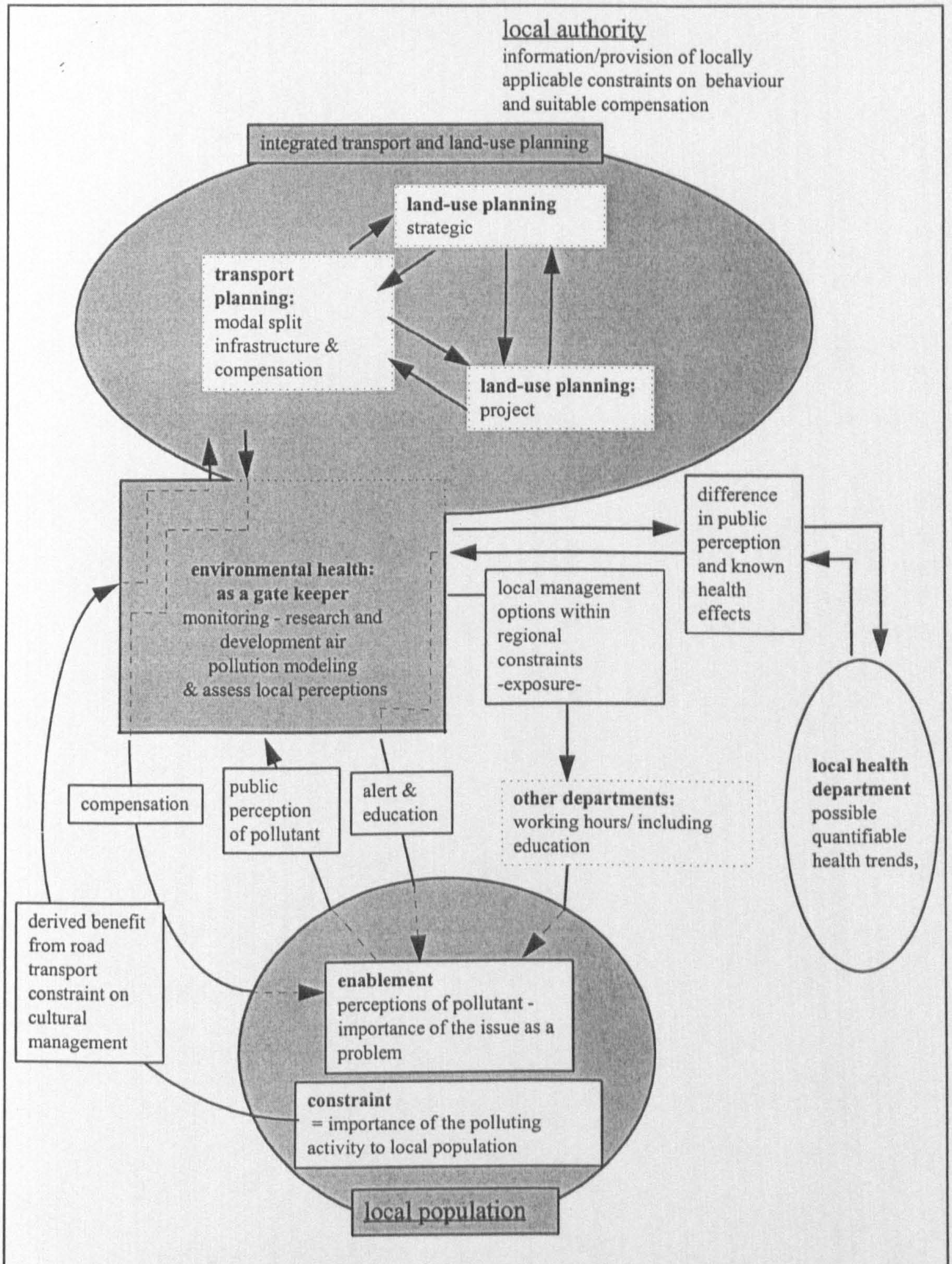


Figure 9-3: A framework for local air quality management

The move towards integration of strategic and project land-use planning and transport planning is recognised as vitally important and is a process that is well underway at present within the Bedford Borough as is illustrated by the quotes:

> *"our divisional heads* [referring to the land-use planning and transport planning departments] *meet and exchange views and personalities do tend to get on well and a good synergy arises."*

> *"However, the process needs to be recognised as a central feature for any interdisciplinary study, a starting block through which the strategy aims are defined and through which analysis and management options are identified. Therefore it must be noted that for the process of integration to work the process itself needs to be given top priority by all departments involved if one would best foster the building of confidence between different sections of the management framework"*
>
> *(Bates 1994).*

9.4.2 Activities for Local Air Quality Management

To a certain extent it is inappropriate to assign tasks to such a working party described in the previous section, in that it is one of the main roles of this working party to liaise within itself and with associated interests to develop its own agenda. This is important since a main role of the process is to allow for a flexible and personality specific working structure to emerge as a mutually co-operate structure, a feature recognised as desirable in the management of environmental phenomena by Hardin in the "*Tragedy of the Commons*" (Hardin, 1968). However, the list of guidelines below shows some of the concerns and approaches needing to be tackled in air quality management strategies and the time scale over which they apply (Cottis 1996). It should be noted that these suggestions are not intended to be prescriptive but the basis of an exploratory exercise. From the research results shown in chapters 5 & 6 it can be seen that novel approaches are in great demand and that measures used may not be generic for all local authorities, but depend on the social and biophysical variation within their localities. What is acceptable in one community may well not be in another.

Short Term

A short term strategy for remedial action through public participation and transport management aims to reduce the needs and desires that the local population satisfy by ownership and use of the private motor vehicle by the provision of viable alternatives and disinducements to use of the private motor car. These should be introduced in light of a research exercise, as is illustrated in chapter 6. Techniques need to recognise the public need and desires regarding transport (Chapter 8).

They may for example include such methods as restricting car use and making less allowances for road building in areas where the general public have expressed a want for public transport due to congestion. Another possibility may be the promotion of a rural, efficient train network in area where accessibility has been cited as a major constraint in the changing of behaviour from public transport (see chapter 6). The application of generically derived methods of changing behaviour to localities on an "off the shelf basis" may result in large scale traffic reduction projects being ignored by the public (Air Health Strategy, January, 1997) or in undesirable emergent social and/or biophysical outcomes (Hadfield, 1997).

Raising the Priority of the issue to the general public.

As in the case of providing alternative modes of transport or traffic management programmes, approaches to raising the priority given to the issue need to be tailored to the values and issues present in the recipient population's every-day life.

- Cross departmental media campaigns on the health effects of, and activities that cause air pollution.
- Promotion of alternatives
- Education programme in schools and colleges
- Alert procedures to impact on public life when air quality is very poor
- Advice on reducing emissions through driver behaviour

A Long term strategy through development planning

- Designing a compact urban structure for example by the use of a green-belt style restriction on urban sprawl (Elsom, 1992),
- Promoting development to suit local needs, i.e. provision of proportionately correct housing in terms of price, size & quality,
- Restricting industrial and commercial growth so that employment can be satisfied by the local population (conservation of urban form),
- Restrictions on planning permission for company or retail car-parking.
- Long term public transport infrastructure development (e.g. urban railways).

Local air quality management can not however be restricted to one locality. Air pollution does tend to have the habit of disrespecting political and administrative boundaries. Therefore if one wishes to progress beyond the management of localised hot-spots, one must look towards regional strategies and working structures.

9.4.3 A Framework for Regional Collaboration in Air Quality Management.

Like the process of management at the local level, regional management can be divided into two separate, but not distinct processes, problem identification and monitoring and a remedial management programme. The nature of the impact that air pollutants can have over regions can be very complex, where often the pollution emitted is quite different both in nature and concentration from the pollution causing concern in the distant location.

The nature of this synergism requires a co-ordinated and concerted effort to manage them (Wolf and Lioy, 1980), especially if one considers that often the most important feature of synergism in air pollution is not just the presence of precursor pollutants but the back-ground ratio of these to each other, and other factors such as local and regional climatic variation. Therefore one can detect the need for a regional framework for collaborative monitoring and managment of air pollutants through which local authorities may negotiate to identify regional managment and compensation strategies in the case where remedial action does not occur or is unfeasible.

9.4.4 A Structural Framework for Regional Air Quality Management.

Figure 9.5 outlines the roles and issues that will be faced by a regional working group, either in the form of a specialist body such as the Environment Agency or as a less formal working party composed just of representatives from local authority air quality management working groups (organised by, for example the association of district authorities, or a group such as SERPLAN).

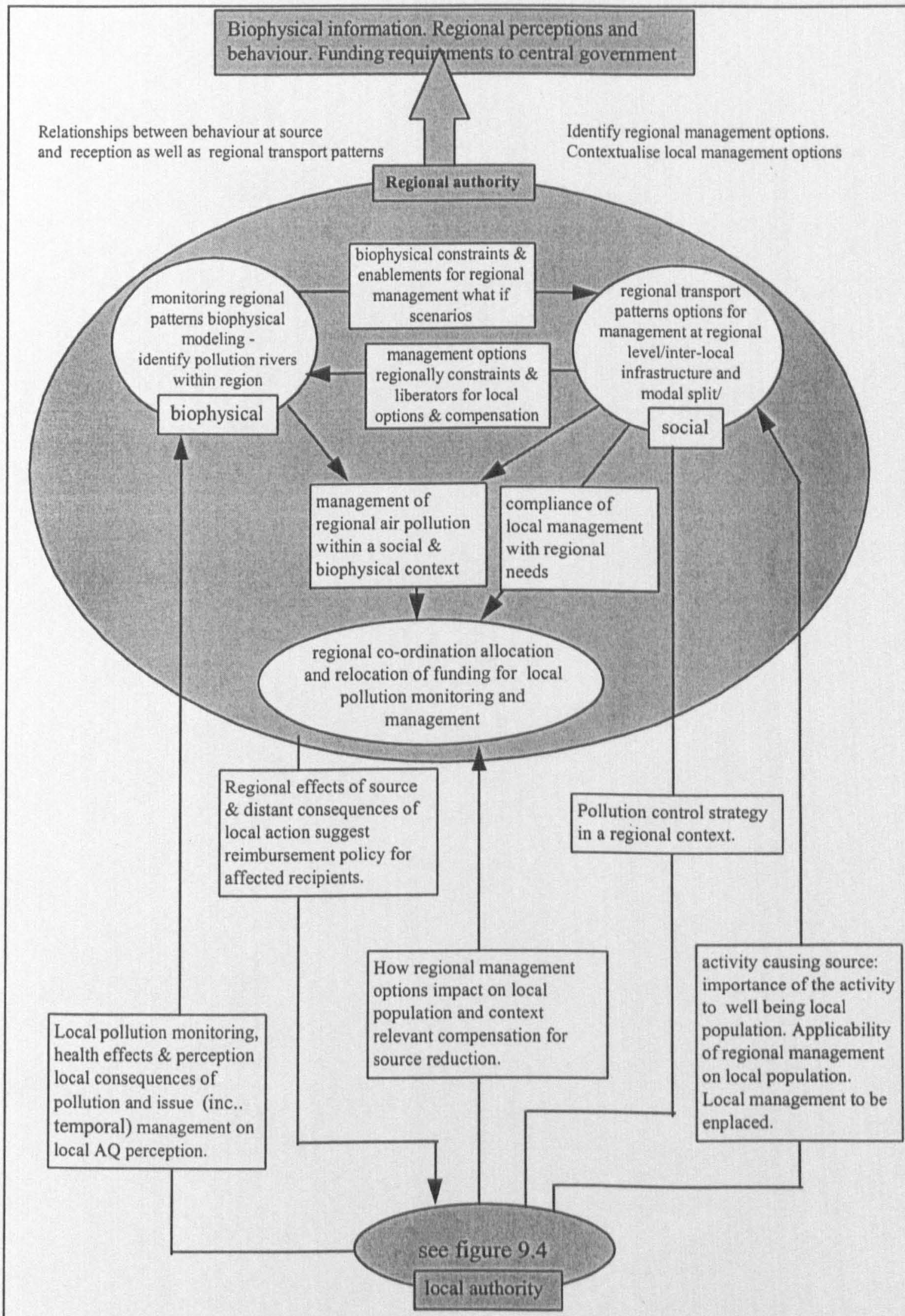


Figure 9-4 : A framework for regional air quality management

The aim of the working group would be two fold:

- to establish the regional nature of air pollution flows and any relationships between different pollutants within these flows, as well as a study of the activities in different areas of the region that contribute to the pollution or that suffer as a result of the pollution (it is recognised here that financial quantification between these costs and benefits to a great extent would be impractical); and
- to relate these regional patterns to local needs and identify methods for reconciling regional management strategies with the needs for local management (it should be noted at this stage the requirement of the 1995 Environment Act is set plans aimed exclusively at dealing with local air quality problems and may therefore represent a constraint as far as this process is concerned).

The description of this process is divided into 3 sections

1. **Biophysical Features.** If consistent approaches to monitoring are used then these may be integrated by local authorities to form a good picture of regional air flows. However as has been noted the choice of monitoring programmes needs to be driven by the atmospheric systems that are responsible for localised problems, rather than guidelines for local monitoring. The information gained from an investigation into regional air flows, sources and impacts can then be used to draw up a list of local activities responsible for these pollution rivers. Table 9.1 shows the required information flows for the design of a regional *and* local monitoring framework.

Table 9-1: Information requirements and exchange between local and regional air quality working groups (biophysical)

information requirements	information flow	
	local authority	regional working group
What are the local problem pollutants & what is the scale of these problems.	→	
What is the relationship between pollutants at different localities.	←	
What pollutants can be managed in a local context.	→	
What impacts on the regional system could local management options produce.	←	
What pollutants an be managed in a regional context.	←	
What impact on local problems could regional management options produce.	→	

2. **Social features** are those aspects of behaviour, or activities that are responsible for the source pollutants within a region. Information over these features can be gained from local air quality management groups looking at

particular areas of high pollution within their jurisdiction and the integration of this data to explore how this behaviour reconfigures over a region (for example how inter-district migration transfers into regional transport flows, working and living patterns). The aim of this approach, supported by social data collected from an exercise such as that found in chapter 7 is to discover the needs and wishes of the regional population in terms of access to transport, for not only local travel but for regional. This data can then be used to inform regional public transport companies, regional transport planers and the DoT. Table 9.2 shows the required information flows for the design of a regional *and* local social monitoring framework.

Table 9-2: information requirements and flows (social)

information requirements	information flow	
	local authority	regional work group
What are the local activities giving rise to pollution sources.	→	
How do these translate into regional activities.	←	
What are the local perceptions of air quality as an issue.	→	
How do these perceptions vary over a region.	←	
What are the locally perceived benefits of the activities causing the source of the pollution.	→	
How does the need to consider these perceptions impact on regional options.	←	

The absence of a requirement for local authorities to monitor and manage regional pollution in the Environmental Act or UK national Air Quality Strategy, does however raise questions as to how funding could be arranged between local authorities, and how different local authorities with varying degrees of political will (Hadfield, 1994) could be encouraged to work co-operatively, especially if one considers the high level of priority given to new working structures that is required if they are to succeed. However the fact that there is a motivation in many local authorities to develop regional working groups (Neighbour, 1996) either as a response to the 1995 Environment Act or as a response to local public pressure (which in itself is variable) does illustrate that there may be potential for such approaches. It is however, the considered opinion of this thesis that the absence of a formal regional structure for the management of air pollution, that can ensure minimum compliance to a regional strategy from all local authorities and allow for adequate and specified funding within a recognised region, is a severe omission from the present formal air quality startegy.

However in the absence of a formal structure one must consider the power of combination and negotiation as potentially powerful tools in achieving co-operation.

High profile projects with the aim of improving environmental quality may result in motivation for other local authorities to come on board either by showing what is possible or by appealing to public sentiments in that area. Funding procedures may be designed from a bottom up contribution to a regional super-fund that allows the regional working party to assign money to specific identified needs. This concept may also be extended to allow for a compensation programme in which an authority receiving pollution from a source area under another's jurisdiction can negotiate compensation from that area on the basis of the "Polluter Pays Principle". However for such a bottom up strategy to work it would be highly desirable if moneys for funding and compensation raised by the local authorities by financial penalties on the polluting behaviour (e.g. parking charges) could be retained by the local authorities to contribute to regional funds, rather than work their way into the national treasury either directly or indirectly. A platform for such an approach, since areas need to be designated around biophysical flows (similar to the catchment concept in water quality management), could be provided by an independent environmental organisation such as the Environment Agency, in order for local authorities that may have conflicting aims to acquire an equal footing for conflict management within the region.

9.5 Summary

The frameworks described in this chapter are not prescriptive approaches but should be the start of a process to encourage professionals within, between, and outside local authorities, and importantly the general public to communicate needs and options associated with air quality impacts and management.

The overall aim of the strategy is not just to hand down policy or restrict development by imposing air quality based considerations as constraints, but to establish a working partnership that can negotiate between the needs and rights of the population to enjoy good local air quality and the needs and desires of commerce and the local population to maintain a satisfactory standard of living that appease as many of their needs and wishes as possible. In this way one may develop an atmosphere of mutual co-operation between decision makers and the recipients of decisions that can be developed towards not just remedial actions but a truly post-hoc approach of identifying and avoiding problems relating to air quality that are yet to come.

10. Implications for Environmental Management and Contribution to Knowledge.

This final chapter gives a brief overview of the work and describes the contribution to knowledge in the field of environmental management that the findings represent.

The first section of the chapter reviews the theoretical framework and locates it within the background literature concerning strategic environmental management. It also reviews the role of interdisciplinarity as a tool for strategic environmental management and the role it plays in improving the understanding of environmental problems as complex social and physical issues.

The second section of the chapter reviews the empirical findings of the research concerning tropospheric ozone in the south central area of the UK. It discusses these findings with respect to this case study as well as from the more generic point of view of strategic environmental management in general.

The concluding section of this chapter identifies the main issues from the research that require further study, these are reviewed in brief due to the fundamental nature of the research and the wide range of issues that it raises.

> *"In reality there is no such thing as the environment, only a set of nested structures which reflect our choice of boundary system.*
>
> *Knowing that this is so is an important step. If we are to learn from the way that the natural world copes with unpredictability and uncertainty we must realise that parallelism, diversity and local freedom are key factors in its ability to cope with whatever happens"*
>
> (Allen 1990)

10.1 Theoretical Overview: The Nature of the Environmental Complex and Interdisciplinarity

One of the first major issues raised was that while environmental management has been a growing subject over the last two decades, there still appears to be little in the way of a consensus over a scholarly robust definition of the term. Therefore the first task of the thesis was to define the term "*environment*".

To resolve this problem the first two chapters reviewed present approaches to environmental management and constructed a theoretical framework. This framework was derived from a variety of literatures from the fields of economics, anthropology and sociology, as well as interdisciplinary environmental management, to support a conceptual model of the environment as an evolutionary construct of people's individual life experiences within the constraints and enablements set by their social and physical surroundings. However, when one considers the nature of the individual in society it becomes apparent that overall perception of what the environment is not merely the result of aggregated and consistent individual views. By interacting in social groups, the individual comes into contact with other ideologies and perceptions which influence their own. Each person's attitudes are the result of their individual life's experience and to a great extent unique to them, including their personal view of what is a desirable environment.

However people also have a tendency to form groups in society, centred around location, occupation or other aspects of association. These have been identified as institutions or sub-cultures. It was therefore proposed that what is considered a desirable or undesirable environment not only varies from individual to individual but also from sub-culture to sub-culture, at different levels.

Consequently a situation can arise where an issue which may be regarded as a specific environmental issue by one person, or sub-culture, may actually be a sub-set of a much wider problem with many other dimensions to it, defined by different people and groups as very different environmental issues. These other issues may be within any aspect of this complex interacting phenomenon that has many interlinked social, political and biophysical dimensions to it. This variation in issue set exists over different spatial scales and varies on the resolution by which it is viewed.

This feature is important in environmental management in that it implies, in a pluralistic society of many individuals living in many different locations and involved in a wide variety of activities, there will be no universally common consensus over what the environment is or what it should be, therefore it is difficult to define the aims of environmental management, for example what form sustainability takes.

The result of these features is a conceptualisation of the environment as a *socio/biophysical complex that forms a co-evolutionary hierarchical structure that can show qualitative and quantitative variation at different temporal and spatial levels.*

Furthermore many features (both social and biophysical) of an environmental issue may exist over different time-scales. While some of these effects are understood and allowed for, some are not and only become apparent after the fact, restricting environmental managers to what are essentially a series of reactive mitigation measure. This feature is demonstrated in this thesis within the history of air quality management, but has also been shown to apply to many other problems in environmental management such as water eutrophication by phosphates (Oxley, 1994; Breeuwsma and Reijernik, 1992),

This problem of variation became quickly apparent in the research where it was recognised that raised levels of tropospheric ozone in Bedford could also be seen as an aspect of the problem of high levels of NOx in London and those resulting from European background flows. Furthermore if the issue is viewed as a problem of the population being subjected to short term high concentrations or alternatively, long term lower concentrations of ozone, the importance of the European and London issues may change.

In addition to this problem it can also be seen as a social issue where the activity of a distant population such as car driving, needed to meet that population's standard of living is having a negative effect on a distant population, who though spatially separate are not discrete.

Environmental issues like tropospheric ozone can therefore be seen to have many technical as well as social and economic components. Furthermore these components do not exist in isolation but are integrally linked and many are influenced by, or even the result of, present and past management practices. This is also true of the present management options that are available for its remediation.

In light of this recognition of the environment as such a varying complex phenomenon, it can be seen that there is a need for an approach to environmental problem solving that can encapsulate the multiscalar nature of both its social and biophysical aspects, by approaching it from an holistic and fully integrated perspective.

Therefore the next problem to be approached was how to integrate this range of different issues into an environmental management programme. The approach used to deal with this problem was the application of the interdisciplinarity paradigm, and raises the second major issue that the thesis tackles, that is what are the implications of this paradigm with regards to environmental policy making? The starting point was to distinguish the approaches of multi and interdisciplinarity.

The approach of multidisciplinarity within the context of environmental management was seen to promote the coupling of established restricted models on different aspects of an environment or development issue, within the perspective of the professions involved, e.g. that of the land-use planner or political economist. It is this present model that forms the basis of many approaches to modern UK environmental policy assessment.

The main features of multidisciplinarity are that goals (often stated in terms of desirable end-states) are set within one particular sectoral agenda or culture. Baseline identification and analysis of different features in the environment tend to be formulated separately within their respective disciplinary frameworks, and any integration that takes place tends to do so in the form of a summary of multiple reports at the end of the process. Therefore while the process does attempt to couple different aspects of the environment it does little to develop an understanding of the relationship between the features that occur in the real world.

In the context of environmental management, the approach of interdisciplinarity is distinct from multidisciplinarity in that it has as a central feature a consideration of the influence that different aspects of the environment have on each other. It allows the analyst a set of tools to view different aspects of the environment in terms of common processes and themes. The driving force behind the use of this paradigm in environmental management has been described by the concept of *ecorealism* (O'Riorden, 1996), where it is recognised that the management of a problem occurs within a set socio-political framework, constrained on the basis of set biophysical flows and relationships. There is a need to recognise the evolutionary dynamic nature of the relationship between these sub-sections of the environment.

By recognising this relationship between the social and biophysical environment, we can see that the interdisciplinary framework presented in this thesis needed to encompass a pathways approach, which recognises that change is an implicit feature of environmental systems. It also needed to be able to recognise the diverse nature of societal needs and desires which are often the cause of the problem, and that these needs and desires are caught up within the constraints of a wider culture showing spatial and temporal variations.

The aim of environmental management therefore shifts from reaching a particular end-state or equilibrium to one of managing change in as resilient and enduring way as possible by an informed approach to resolving these, often conflicting issues. The proposition was that environmental management is not just a technical issue, but one of how to represent a wide variety of needs, desires and values in as sustainable a way as possible.

10.2 Building an Interdisciplinary Approach to Environmental Management: A contribution to knowledge.

The validity of the theoretic framework presented in this thesis was explored through substantive investigations into the nature of the social and biophysical systems inherent in the issue of tropospheric ozone in the south central area of the UK.

The main features of these findings were that:

1. Both biophysical and social systems show qualitative and quantitative variation between different scales and between different locations within the same spatial resolution (Chapters 6 & 7);
2. Management programmes in one locality can severely restrict options at another, or options taken on at another scalar resolution (Chapter 6);
3. Problems of degradation in one area can result from the needs and desires of a population in another (Chapters 3,6 & 7);
4. Management programmes aimed at controlling particular activities in a specific location must recognise the needs, values and desires of the population in that location, beyond the purely economic. These have been shown to vary at a very local resolution (Chapter 7);
5. Present management approaches are to a great extent the product of past problems and working practices. They are not always suited to contemporary problems and may restrict present management practices and options with regards to present needs (Chapters 4 & 5);
6. With respect to the management of tropospheric ozone there is a general incongruity between the present strategic air quality management framework in the UK and the social and biophysical systems inherent to the problem. This incongruity derives from the essentially top-down structure of the UK policy framework based within a strong control culture that it is felt restricts local authority management options and poorly fosters inter-local authority communication (Chapter 8);
7. Public involvement programmes tend to be based within the welfare paradigm (Chapter 7) and are inefficient in identifying the range of local needs and value sets inherent in public activities at any particular time, within any particular location. Public education programmes need to foster a two-way flow of information between the decision making framework and the population within which it works (Chapter 9).
8. Strategic air quality management needs to move away from control and prescription of local activity to one which can foster a milieu that promotes and informs the recognition and negotiation of conflicting desires. This requirement suggests a need for a transformation in the culture of the strategic framework from a strong uniculture to a more flexible pluriculture both between tiers and within each tier of the

management structure as well as between the decision making bodies and the general public. The aim of this structure is to identify and foster the framework's needs for the wide variety of local and regional data concerning both the social and biophysical aspects of the problem, and to communicate these effectively between different tiers and within each tier of the policy framework. The framework needs to recognise the importance of local monitoring and initiatives in order to establish local aims around local desires while recognising the importance of a top-down regional co-ordination process.

The identification and illustration of a theoretical construct of what the environment is, supported by findings derived from empirical studies into air quality flows, social needs and values surrounding the cause, transport and reception of the pollutant (Chapters 5 & 6) and an in-depth review of different activities within different tiers of the management framework (Chapter 7), has allowed the study to:

1. Comprehensively critique present problems and issues in the framework promoted by the UKNAQS and the 1995 Environment Act with regard to tropospheric ozone; and
2. Develop a method for designing a strategic framework for the management of this diffuse, regional pollutant that results from wide spread legitimate human activity.

These exercises represent a distinct and novel contribution to the field of air quality management as well as strategic environmental management as a whole, as does the methodological work concerning the development of this framework.

10.2.1 Building the Framework.

The first step of the framework was to develop a focus for the issue under investigation and to establish boundaries over which causes and effects operate. This stage essentially equates with the scoping exercise typical in strategic environmental assessments (Therivel, 1994). However, unlike the traditional approach, this stage is not discrete from the following stages of the framework; the analysis of the social, biophysical and managerial systems inherent to the issue under investigation. The "scoping exercise" size consists of:

1. A recognition that integrated analysis of an environmental problem is not a simple task, if for no other reason than the implicit complexity of the environment as a subject. Therefore a necessary first step in designing a management framework is the abstraction of the issue down to a manageable form. A useful approach for doing this is to focus on one main problem, this has been termed the *issue led* or *environmental problem* approach. This allows for the design of a relatively simple structure that can encapsulate the complexity inherent to the recognition of the environment as a co-evolutionary socio/biophysical phenomena. It facilitates a strategic management framework in being selective among the wide range of social and biophysical information and data that is at hand.
2. The next stage is to identify data sets and scales relevant to the issue. Approaching problems of defining and mitigating environmental degradation in this manner needs input from social, biophysical and managerial knowledge sets. The need for the input and integration of these knowledge sets in the design of the framework requires input

from these fields at an early stage of the policy analysis. However the role of these specialisms is more one of informing the integrated process than driving it.

The next stage of the analysis is then to identify the qualitative and quantitative issues associated with this problem over different temporal and spatial scales, by liaising with chemical, environmental and social expertise and knowledge sets relevant to the issue. The aim at this point can be understood in the context of who, what, where, when, and why.

This part of the analysis comprises of an iterative investigation into the biophysical and social aspects of the problem that informs the framework design as to its possible boundaries and the nature of the socio/biophysical system within those boundaries. For the sake of clarity these are presented separately but it should be kept in mind that they are closely inter-connected.

10.2.2 Looking at Biophysical Flows

The main features of this stage are that:

- It aims to build up from the focus point (or issue) to identify the scale over which the effects of the problem occur. It needs to establish how the issue affects other features of the social and biophysical environment as well as how these effects translate into other issues. Important features are how these issues change, quantitatively and qualitatively at different scalar resolutions as well as from location to location.
- It needs to identify possible time scales over which events can occur, and make an informed judgement as to any future consequence present action may have for the biophysical systems involved. Chapter 6 illustrated how this approach can be used to look at an air quality management issue. This chapter also illustrates some of the constraints that the biophysical system imposes on management options and some of the enablements by illustrating the potentially wide range of intervention.

The overall aim of this stage of the management is centred on identifying people affected (either positively or negatively) by the issue, the physical mechanisms by which they are affected and possible intervention strategies. In this way one attempts to develop an understanding, or model, of the situation in terms of its physical nature therefore allowing the manager or analyst to ask a series of "what if" questions over the behaviour of the biophysical system, when subject to a series of intervention strategies. In this way one may gather information covering the possible losers and gainers from any of these strategies in order to develop compensation or mitigation strategies.

10.2.3 Examining the Social Context

The previously described stage in the framework aimed to identify and locate the activities affecting the system, the benefits that these activities supply to the individuals concerned and how people affected by disbenefits may be disadvantaged. However, here one must also remember that the individual is the central person to their own lives and their response to the effects are essentially determined by how they perceive the effects of actions on their social and physical environment. Therefore consequences cannot just be judged on best scientific knowledge concerning how environmental degradation may effect the population especially where this knowledge is incomplete. It needs to be recognised that responses to environmental degradation will be greatly influenced by the way this information is interpreted through the lenses of a variety of different cultural issues and value sets. The role of this stage of the analysis was therefore to find out how the individuals affected by different parts of this system perceive the benefits or disbenefits in their lives on any policy or action, and how any accompanying remedial or policy options are likely to be received by the recipients. This process has been identified as an essential feature of any environmental programme in identifying both applicable and acceptable alternatives to the activities causing the problem. This requires research into how different activities translate into the personal well being of those people who are involved; i.e. are the qualitative as well as the quantitative gains and losses experienced by people as a result of action.

This approach represents a distinct shift from the present approach promoted in the UK National Air Quality Strategy of changing behaviour through education programmes into air quality mixed with economic coercion. The failings on this approach are summarised below.

10.2.3.1 Problems with pricing mechanisms

The present dominance of the economic approach for effecting change in behaviour is incomplete. It neglects the highly variable aspect of personal needs and values by assessing the aspects of utility surrounding an activity in a much too restricted agenda. This feature was illustrated with respect to car use in Chapter 7. The findings of this chapter show that in reference to private car use any loss resulting from the coercion of the population away from the use of this form of transport is poorly reflected in the economic paradigm since the activity fulfils a wide variety of direct and indirect functions to individuals.

The approach has the problem of imposing a single perspective on a subjective issue and often poorly represents the actual value people themselves place on the environment. This has led to comments such as:

> *"This school of economics offers us an impoverished theory of choice which explains, and then incompletely, only those choices driven by self interest. The rest of the rich spectrum of human choice- habit altruism, convention, coercion, aspiration and so on are completely ignored"*
>
> *(Burke 1997)*

Burke then goes on to state:

> *"Cost-benefit analysis is a wonderful device that allows you to go on and break one of the first rules taught to you at primary school, and add apples and pears"*
>
> *(op cit.)*

This problem, is termed in more dry terminology by Ahuja (1996) who notes that:

> *"the basic assumptions of the "Property Rights" school are too restrictive to be useful in the design of policies and guidelines for sustainable management of the natural resources"*

(*Ahuja 1996*)

It may also be what was meant in a comment by General DeGaul in 1969 when he stated that;

"It is difficult to govern a country of 59 different types of cheese".

However, at present this problem is not trivial since most public policy, especially that concerned with environmental management, is subject to strict analysis using cost-benefit techniques (DoE, 1991). The popularity of this approach in the environmental field has been put down to the fact that policies favoured by this approach tend to appeal to the political sphere in that they are good revenue raisers while pacifying the environmental lobby by producing a visible punishment on polluting behaviour (Burke, 1997).

The process of changing behaviour needs to be set within the context of the population values, needs and activities. To achieve this social aspects of strategic management need to be recognised through a mutual information transfer between the policy framework and the population with which they interact.

10.2.3.2 Problems with education programmes

With respect to car use these were shown to be based on the public welfare paradigm, where policy is enacted by unidirectional flows of information. This is typical of the prescriptive approach to environmental and public policy derived from technically led frameworks such as multidisciplinary analysis. However, they do neglect the knowledge sets and opinions that exist in the population at which they are aimed. Furthermore, they also neglect the wish or ability of different sectors to identify or respond to that information within their personal life-styles. Education programmes, like any supplied alternatives, need to be applicable and acceptable to the population at which they are aimed. This requires a mutual flow of information from the decision making body to the population and back. Information originating from the public must be recognised and acted upon, otherwise it is likely that education and policy initiatives in general will be ignored or resisted.

10.2.4 Investigating the Managerial and Policy Culture

Management options however, are not merely constrained by their acceptability or relevance to the social and biophysical systems at which they are aimed. Often, there are many bodies dealing with different parts of this system which are constrained by both the intra- and inter-departmental relationships and agendas of the institutions forming policy concerning separate parts of the problem.

These relationships and approaches have in many cases emerged from the historical practices of the organisation concerned, approaches that have been developed to deal with past problems that are quite distinct from those being dealt with at present. At this point an analysis needs to study the culture and attitudes prevalent in the tiered organisational structure involve in managing different aspects of the problem, in order to identify constraints and feedbacks within this culture that affect the option space of each tier of management. The aim is to identify the most suitable form of interaction in dealing with the problem at the most suitable level with regard to both its social and biophysical aspects, as well as any changes that the management structure itself may have to go through in order to deal with the problem effectively.

If one considers the nature of these concerns with respect to tropospheric ozone it can be seen that there are a number of agendas involved in the issue of air quality and environmental health comprising a range of legislation centred around the control of different pollutants at point source and within local level areas. These agendas involve local and national economic development and land-use planning including local commerce and housing management with their own historical context of encouraging mobility and dispersed living patterns.

The framework here approaches this issue by stressing the need to form a basis where each of these issues and agendas can be formulated and communicated to each of the other management concerns at a suitable level to allow conflicting issues and opinions to be discussed and resolved. This activity stresses the need for networking, or what Hardin (1968) terms mutual coercion between interested parties. This needs to be carried out between tiers and within tiers of government on what needs to be termed a truly level playing field rather than the pushing of one agenda on another. Each participant in this process needs not only the ability to bring the commitment of their respective department to this process, but to be able to debate their stance in an influential manner.

The approach can be seen as necessary in a pluralistic society since consensus is often hard to achieve, if indeed it is possible to achieve it at all. The stress here therefore rests on formulating a common ground. This will not be a desirable position for all, but a position that is at least tolerable to the parties whose co-operation is required. This brings in the concepts of subsidiarity and integration.

While in the air quality example it is stated as central government's position that they recognise the importance of sustainabilty, there is little evidence of a true understanding of what the concept involves as a dynamic relationship. Chapter 9 argued that the concept sits poorly in a top-down political framework where goals and budgets are set by the top tier of government. Methods of incorporating a proportional and more equal system of representation between local government and central government within environmentally relevant policy formulation are therefore an identified area for research. It should also be remembered that the approach adopted to examine this subject area must recognise the importance of the evolution and existence of the present structure and the vested interests and agendas it represents.

There is also a similar problem to be found within the managerial structure at each level and this is related to the multiple boundary nature of the air pollutant itself as well as the derived function of the behaviour causing the problem. As professional association gives rise to working practices centred around issue sets within each profession or discipline, so approaches to dealing with these tend to develop. In an institution with a historically strong departmentalised structure, these departments may develop quite discrete working practices, or what have been termed in this document "cultures". These may be centred purely around a discipline or more commonly are a function of the discipline and other sub-culture variations such as location. The result is that varying approaches exist in environmental management between and within local authorities.

However, many problems of environmental degradation faced today are formed by meso and large scale biophysical flows and influence many spheres of interest, and indeed this can be seen to be the case with tropospheric ozone. Suggestions of formal frameworks that would allow integration across local authorities and within local authority departments are introduced in chapter 9, but are in no way prescriptive. As Bate (1994) points out, a main reason for this is that every organisation's culture and sub-cultures are to a great extent unique functions of that culture in much the same way as people's personalities are a function of their own life history (Hagerstrand, 1970). Therefore to strategies for cultural change need closely fitting to an organisation in much the same way as strategies for behavioural change need to closely fit the population at which they are aimed.

10.3 Suggested Areas of Research

From the work presented in this thesis it can be recognised that there are implications for further research at two levels: firstly implications concerning research into air quality management of the regional production and reception of tropospheric ozone, secondly more generic implications for strategic environmental management as a whole.

If we consider the case study of tropospheric ozone we can see useful research to be carried out would be context specific ozone and precursor monitoring to ascertain the relevant responsibility that London has concerning Bedford's ozone levels, especially with respect to what may be a dampening effect from London's NOx levels on ozone levels to the north-west in general. At a more local perspective one would need to carry-out a what-if analysis of a concerted traffic reduction programme in Bedford itself with respect to the possibility of raising the ozone levels in this area due to a reduction in NOx as well as how any change in pollutant concentrations would actually affect the population in terms of their health as well as their concerns and general well-being.

In designing a regional monitoring programme one faces the issue of co-operation and cost sharing between local authorities and the needs of each local authority to meet commitments under the 1995 Act. The approach suggested in chapter 9 to setting up a platform for this is based on the concept of networking between senior members of the local authority departments concerned. However, it is recognised that these people bring with them cultural value and language sets which can constrain this process. Research into methods for arriving at a common and shared platform for aligning these value sets in air quality management is needed. A specific issue to be considered would be the role of associations of authorities working on their own or possible roles for an independent co-ordinator, such as the Environment Agency.

This need is also recognisable between the local authorities and the population. Research needs to identify: suitable methods for assessing the relative importance that all people in the respective communities place on transport and clean air; how the issue should be raised and how a population's needs in one area can be compensated for to produce benefits in others. Like the air quality data, social monitoring needs to be close enough to the local population to account for the variation in needs and desires but communicated and co-ordinated on a regional basis. Such an approach to integrating popular concerns in policy are needed if suitable information platforms are to be established with regards to communicating the issue of air quality. There is a recognised need for research into how one can approach an institution and influence both the implicit and explicit aspects of a "segmentalist culture" at a departmental as well as an individual level, concentrating of methods for resolving conflicts of the vested interest (why), over-coming professional assumption (how), conflicts in priority (when) and responsibility (who).

However perhaps the most challenging task facing research is to design and implement a theoretically robust modelling framework that can explore how these features inter-relate. This will need to go beyond the present approach of designing and amalgamating disciplinary models. The need is to design simple but theoretically consistent models to represent the complex interactions between social, biophysical and political systems involved in the design and implementation of air quality policy. The need to develop a consistent and common paradigm is approached in chapter 2, a logical next step would be to formulate this into a product that can be taken to professionals involved in strategic environmental management. The product may take the form of either a computer based training package, or a set of structured workshops constructed to communicate the framework presented in chapter 9. In either case the need is for facilitating the interaction between interdisciplinary scientists with managers who are involved in the every day tasks of designing and implementing policy to allow for the exploration of alternatives and the synthesis of issues and solutions with regard to the physical, social and managerial dimensions of air quality management.

This applies not only to air quality problems but to any modelling and management framework aimed at the management of dispersed and behaviourally derived pollutants. The complexity and interrelatedness of co-evolutionary socio/biophysical problems needs to be recognised and would require the development of techniques of knowledge sharing between a wide range of disciplines. Once this is ascertained a better understanding of viable management strategies could be gained to allow informative consultation with the populations any strategies may affect.

10.4 Summary

Essentially the aim of the approach presented in this thesis, is to move away from basing environmental analysis on purely economic or epidemiological health considerations to one that can identify and account for the wide range of social values attached to the issue. These may range from the wish to ensure individual economic well being in the long and short term, and those connected with cultural value sets (such as family tradition) and concerns over health and well being that are often scientifically unproved but still legitimate to the population at large.

The traditional principles of best scientific knowledge as a driver of environmental policy mixed with the use of financial incentive/disincentive is seen as too restrictive an approach for many of the complex, behaviourally derived and wide-spread pollution issues society faces at present. In air quality management it can be seen to be encouraging a policy approach that essentially treats modern air pollutants in a way similar to the 1950s, that takes little account of the role the behaviour causing the problem has in terms of either its advantages or disadvantages on people's everyday lives. The resultant Environment Act and UKNAQS tries to manage regionally and nationally dispersed complex pollutants as discrete local (authority?) problems, based on the concept of individual Air Quality Standards. This approach bears little resemblance to the way the pollutants are produced or behave in the atmosphere.

While many aspects of the UKNAQS report are commendable, the main problem for environmental management is not lack of scientific knowledge or regulatory clout but how modern society has been managed with regards to its effect on the social and physical environment. Effects of pollution are still essentially considered in terms of human health (a tradition originating in the 1800s) instead of as symptoms of behavioural patterns which damage a part of the environment on which we, as a species, depend for our well-being. The degradation of this part of the environment is not a technical problem but one of management (Viessman, 1988).

Indeed, nearly all air pollution related threats to human health in urban areas would to a great extent be solved if that other feature of urban well-being, the motor car, could be managed. Nevertheless, while the Environment Act firmly lays the responsibility for improving air quality on the steps of already besieged local authorities, Downing Street for many years has been occupied with other priorities such as the privatisation of public transport and the introduction of ever larger lorries. It is difficult to see how the Act can produce any significant effect.

Strategies aimed at environmental management must take into account the social and political structure that they have to work in, a structure that is variable across many cultural parameters and often distant to the surroundings in which the manager is working in. This brings in the concept of equity in that one must realise that needs and life-styles that are not in concordance with those that the decision maker experiences as justified or desirable are still often legitimate to other parts of the population. Disregard for this feature can create significant problems for any strategy.

Thus a new approach to environmental management is needed, one that can influence our national culture as a whole, and is generally acceptable (or at least not totally unacceptable) to the individual and the nation alike. This would not only require scientific understanding, but also a deep societal understanding of the causes of the problem and their relation to people's lives.

The role of the interdisciplinary scientist is to liaise with specialists to allow a construction of the problem in terms of its wider systemic properties, to identify the associated issues and concerns that these processes produce in different locations as well as the way these problems reconfigure. This requires an ability to draw information from social and scientific sources and explore ways of combining these data sets to allow the exploration of future scenarios. This approach will allow an integrated strategic framework to define not only the best approach for solving present problems but may provide environmental managers with a tool for anticipating ones that are yet to happen.

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Interviews with Author

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Resolving the Strategic Gap in Environmental Management: Tropospheric Ozone In Bedfordshire (Volume 2: Appendices and Tables)

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PhD Thesis

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Resolving the Strategic Gap in Environmental Management: Tropospheric Ozone In Bedfordshire (Volume 2: Appendices and Tables)

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March 1998

Appendices

Appendix 1: Associated Papers

An Integrated Investigation into the Scientific and Social Aspects of Air Quality Management: Understanding the Whole Picture.

Linda Hadfield & Gen Cannibal (1996)[1]

Abstract

Environmental effects such as the impact of traffic pollution on human health are subtly complex, emergent problems, which cannot be managed adequately within existing analytical approaches and institutional frameworks. Using a case study of transport related tropospheric ozone management in the South Central region of the United Kingdom, this paper demonstrates that the management of complex regional problems requires both a thorough understanding of the natural processes involved, and a recognition of differences in perception and institutional responsibilities at different geographical scales.

Introduction

> *"Of all air pollution problems (...) Ozone is acknowledged as the most complex and controversial. Unfortunately, the reasons why the O_3 problem still exists are unclear"* (Huess & Wolffe, 1993)
>
> *"But in this part of South-East England, that's just the way it is, we haven't got industrial polluters, we've got traffic and god knows what we're going to do about it" (A Local Environmental Health Officer, 1995).*

Present approaches used in environmental planning are deeply rooted in the rationalist paradigm which has dominated the discipline of planning over the last fifty years. However environmental effects such as the impact of traffic pollution on human health are subtly complex, unpredictable, emergent problems (Cannibal and Hadfield, 1995). In this paper we argue that the management of complex regional problems requires a shift in paradigm, and that while a thorough scientific understanding of natural processes involved is needed, the present analytical approaches and institutional frameworks are too restricted to cope with such complexity, leading to such quotes as those at the top of this page.

Using a case study of transport related tropospheric ozone management in the South Central region of the United Kingdom, this paper demonstrates how a multi-discipline, multiple perspective approach can shed new light on the problems a comprehensive management framework must address if it is to deal adequately with the issues surrounding such a complex problem.

Tropospheric Ozone: A case of complexity

Tropospheric ozone is a naturally occurring trace gas produced from the photolysis of Nitrous Oxide (NO_X) there are very few direct anthropogenic emissions of ozone. The genesis of tropospheric ozone result from the interaction of two main precursors both of which while present naturally, are also produced in significant amounts by industrial processes and automobile emissions. These are the nitrous oxides and volatile organic compounds (VOCs). Furthermore the genesis of ozone is also influenced by climatic factors such as sunlight and wind conditions.

[1] Hadfield, L. and G. Cannibal (1996). *An Integrated Investigation into the Scientific and Social Aspects of Air Quality Management: Understanding the Whole Picture.* in Hickey and Kanterelis: *Our Natural Environment:* 2nd International Conference of the IEA, Rhode Island, USA, IEA.

While the actual chemistry of tropospheric ozone is poorly understood, the nature of these emissions has been studied in depth.

NO_x is a generic term given to nitrogenous oxides and is essentially composed of Nitrogen Oxide (@ 90%) and Nitrogen di-oxide (@10%). In the absence of anthropogenic emissions NO_x is present in the atmosphere at very low concentrations (resulting from microbial activity) and at these concentrations forms a vital link in the nitrogen cycle. However, NO_x is also produced as a significant bi-product of fossil fuel combustion in electricity generation and as traffic exhaust emissions. NO_x has been implicated in the formation of acid precipitation, human respiratory diseases and high levels of tropospheric ozone (Badr and Probert 1993). At present in the United Kingdom there are set guidelines and permissible levels for NO_x (see section). However it is recognized that the guidelines are often exceeded in urban areas (QUARG, 1994) especially in the winter months.

VOC is the collective term given to a wide range of organic compounds, most of which are hydrocarbons. While VOCs are often treated generically in pollution studies they do in fact represent a wide range of compounds with differing reactivities (therefore transport rates) and various health effects such a that of benzene which has been linked to cancer. Unlike NOx, VOCs come from a wide range of sources and are present from natural source in varying but significant concentrations (Chameides 1994). Main anthropogenic sources include transport (@ 40%), and industrial solvent use (@ 45%). While there are distinct seasonal and diurnal variations in the emissions rates of these compounds, the multiple source nature as well as the long life times of these products leads to the concentration of these substances in the air being fairly stable. VOCs are limited under the United Nation VOC protocol. At present there are no set standards for the control of VOCs as a group within the UK.

The relationship between ozone and its precursors

While the chemistry of ozone formation in the lower atmosphere is extremely complex and poorly understood, the detailed chemistry involves various non-linear interactions involving a whole range of compounds with different emission rates, lifetimes, and transport rates in the presence of meteorological (and possibly chemical) catalysts (PORG 1993). However the basic mechanics of ozone formation and the duel role of NO_x are well understood.

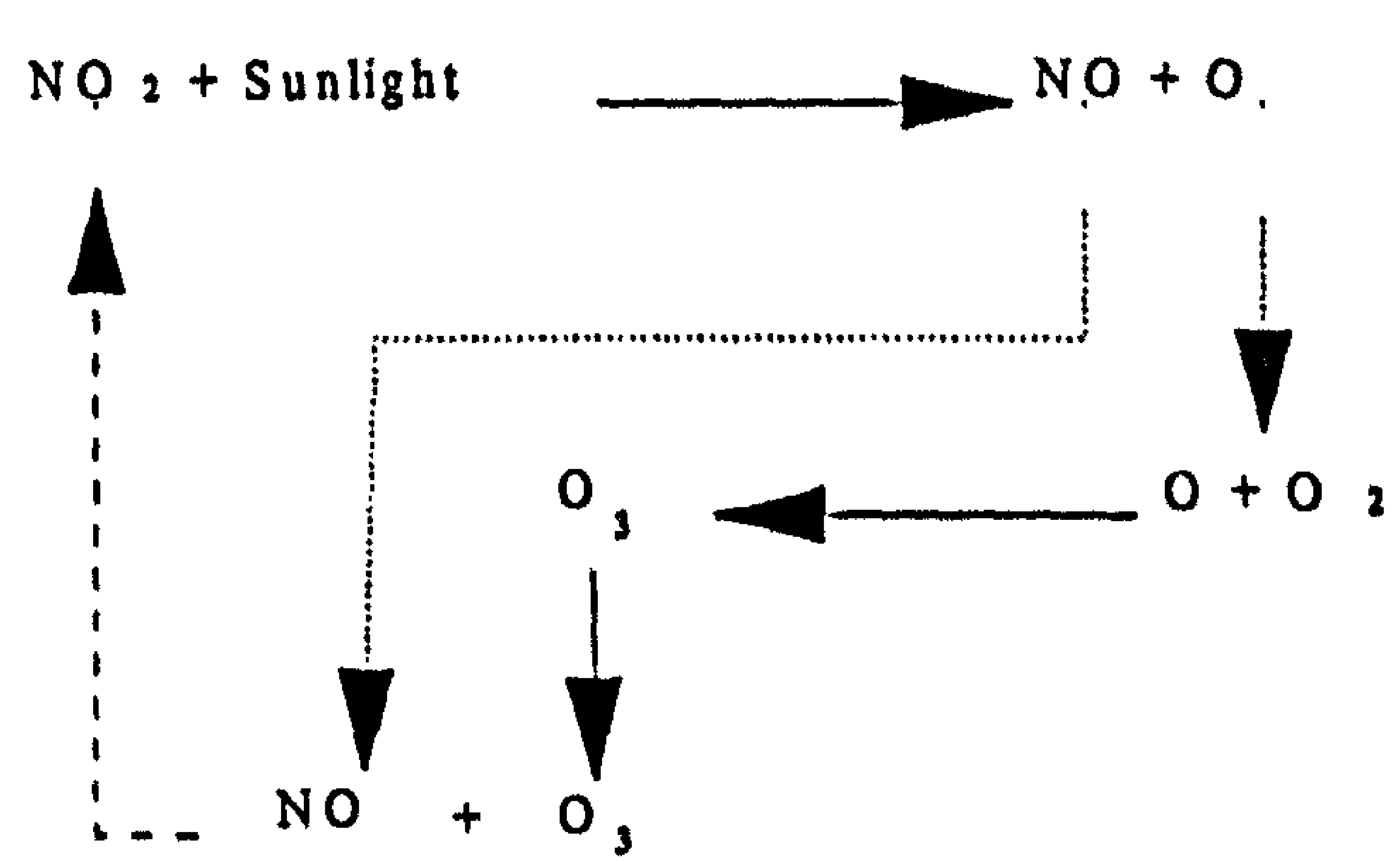

Figure 3: the Photolysis of Nitrogen Dioxide

In the absence of volatile organic compounds ground level ozone if formed from the proteolysis of atmospheric nitrogen dioxide (NO_2) (See figure 1). In this reaction NO_2 splits in the presence of sunlight, to produce nitric oxide (NO) and a free oxygen radical, which then combines with atmospheric oxygen (O_2) to form ozone. The ozone however freely reacts with NO to produce O_2 and NO_2 thus creating a photostationary equilibrium (DoE 1994).

However, in the presence of the VOCs and their derivative radicals (RO_2) the nitric oxide is extracted from the system to produce NO_2 and the highly reactive VOC radical RO, therefore the level of NO available for the degradation of ozone is effectively decreased and ozone accumulates in the atmosphere (see fig. 2).

However a final stage in this equation is the reaction of RO with atmospheric NO_2 (Huess and Wolffe 1993) to form stable products. The effect of this stage in the reaction is the removal from the atmosphere of NO_2 that is open to photolysis, and thus ozone formation is curtailed.

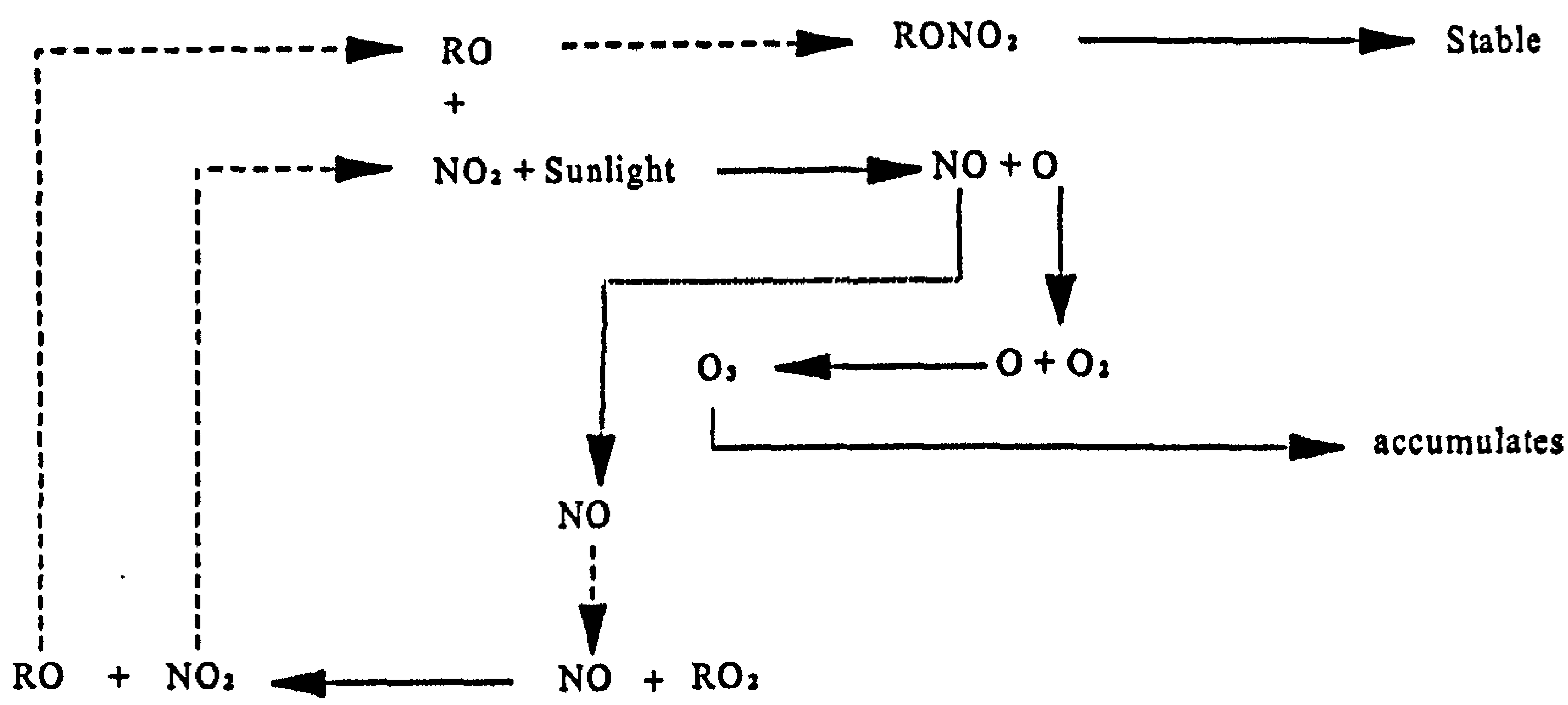

Figure 4: The Dual Role of NO_x in Tropospheric Ozone Production (after Heuss and Wolfe 1993)

The genesis and accumulation of ozone from NO_x and VOCs, occurs over a scale of several hours (McKendry 1992) downwind of areas typified by high NOx and VOC concentrations. This leads to the formation of ozone rivers where densely populated urban area acts as sinks for ozone precursors, while the ozone concentration is fairly low due to scavenging by the high concentrations of Nitrogen oxide (McKendry 1992). Ozone concentrations increase down an urban plume and accumulate in more rural areas down wind (see fig 5), an effect that may be hightened if there are significant emissions of natural VOCs in the rural area.

Ozone genesis is also dependent on temporal factors particularly diurnal and seasonal. The concentration of tropospheric ozone varies markedly from summer to winter, with high concentrations occurring usually in the summer months. Conversely NO_x pollution events are a feature of the winter months where scavenging by ultraviolet radiation ($h\nu$) is greatly reduced (Hecq, 1993).

Policy Implications

The result of these spatial and temporal effects is that while high ozone concentrations are associated with rural areas, and high NO_x events associated with urban areas, both tend to be managed as separate pollutants, and are particularly contentious issues at different times of the year.

At present ozone abatement strategies in both the USA and Europe have concentrated on a rather rigid structure of control policies of the precursor emissions at source (DoE 1994, Chameides 1994), with emphasis placed on the role of 'technological fixes' such as the three way catalytic converter (QUARG 1993). Within the United Kingdom the goals of these control strategies is firmly based within the framework of air quality criteria (set initially at the European level). These criteria are to be implemented at the local level and are based on health effects of individual pollutants (DoE, 1995).

This however contradicts many of the recognized features of how NO_x, VOCs and tropospheric O_3 interact. One of these features is that ozone control strategies depend on background precursor concentrations. When the ratio of VOC:NO_x is relatively high the preferred strategy for ozone abatement is NO_x control. When the VOC:NO_x ratio is low VOC reduction strategies are preferred (Chamiedes 1994). At intermediate concentrations reduction of both precursors are effective but at levels far less than proportional since the VOC:NO_x ratios are kept at optimum (Huess & Wolffe 1993).

Secondly the migrant and synergistic nature of ozone means that for this pollutant the source is distant from the perception of the problem. NO_x and VOCs are pollutants in their own right with associated health effects as severe as those of ozone and therefore have set air quality

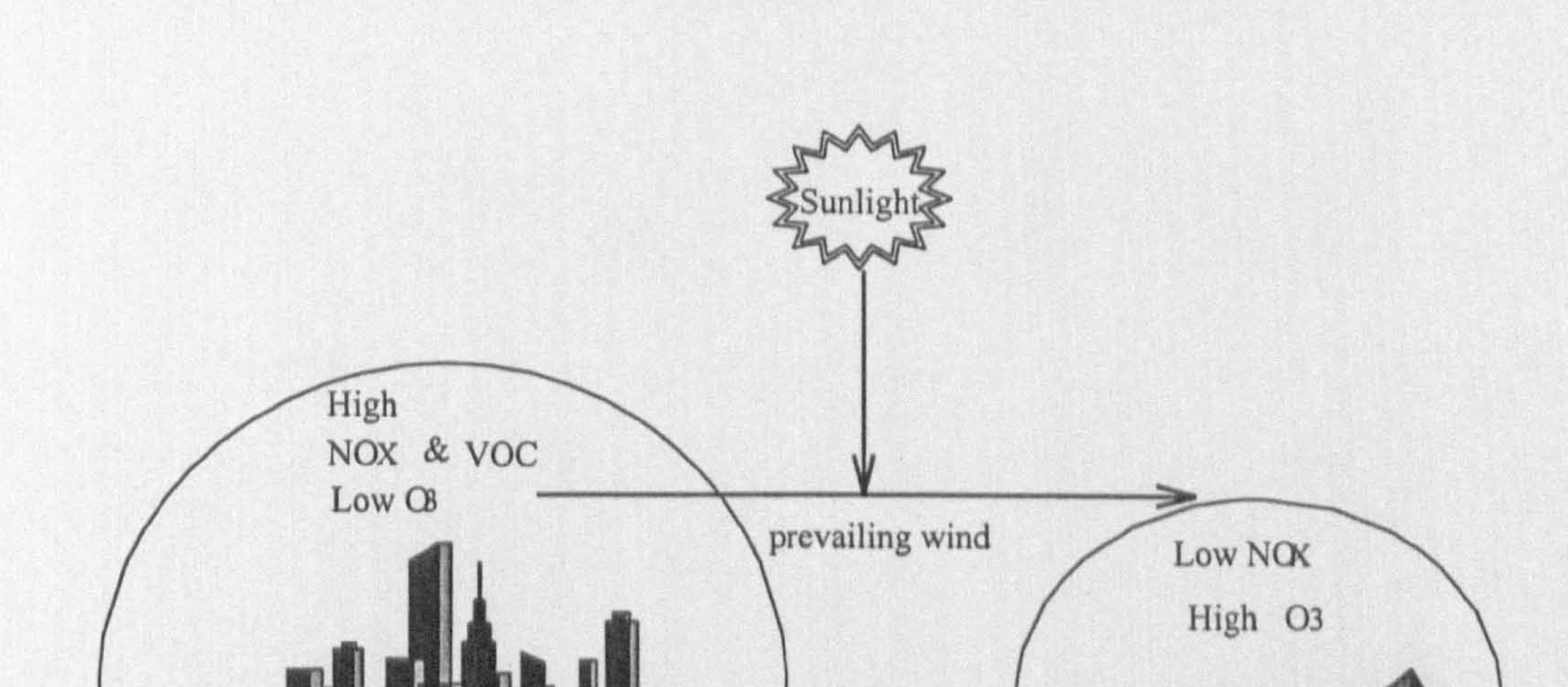

Figure 5. Migration of an Ozone River

standards. Furthermore, due to the nature of the relationship between NO_x, VOC, and ozone the localities where NO_x or VOCs are problem pollutants tend not to be the areas where ozone is a problem. In effect the same pollution incident shows itself in different localities as different pollutants and therefor strategies for management are segregated. However due to the complex nature of the NOx/VOC reaction, control strategies need to be very finely tuned throughout the whole region.

Given this situation it can be seen that local emission controls in a rural or semi-urban area could be inefficient in reducing the magnitude of the peak tropospheric ozone concentrations and may actually lead to an increase in ozone concentrations. Vehicular emission controls in the more densely populated urban areas may result in reduced downwind ozone concentrations (Sienfield 1993), although the effect of this still remains unclear, it may well be possible that this strategy may be compromised by rising levels of urban ground level ozone (*The Times* 1995).

The generation and dispersion of ozone and its health effects creates its own geographical boundaries. However, ozone, and air quality in general, is just one set of issues to be tackled within an existing structure of local government, which in itself is still in a state of flux due to the phasing out of the two tier (county and district) authorities as well as the trend towards transfering functions from the public sector towards the private.

In a democratic and pluralistic country such as the UK, many issues are decided on a day-to-day basis at the local level, by the actions of individuals within local authorities. These include both elected members and professional officers as well as individual members of the general public. The local authorities are in turn accountable to the residents and electors in their districts, who have their own perceptions and agendas (Lemon 1991).

The following case study looks at the ways in which issues of air quality management have in the past been approached by a group of 13 local authorities in a particular geographical location. The perceptions of the local authority environmental health officers in those districts, and the perceptions of residents within the regions.

Ground Level Ozone in Bedfordshire: A Real-Life Problem

Data in this part of the paper were taken from two studies carried out in the summer of 1994, and ozone monitoring carried out by Warren Springs Laboratory (now NETCEN) on behalf of Bedford Borough Council during the summers of 1992, 1993 and 1994.

The first study was a series of interviews carried out with local government environmental health staff in thirteen local authority districts in the counties of Bedfordshire and Hertfordshire, to the north of London. The aim of the study was to establish what air quality monitoring was currently being carried out in the different districts, and what were considered to be the main sources of pollution, with a view to developing a joint air quality monitoring strategy for the two counties region.

The second study was an attitude survey of three hundred households in nine locations in and around the town of Bedford, the largest urban area in the north-western part of the region, aimed at eliciting public perceptions of local air quality, of the main factors affecting local air quality, and of public understanding of and concern about the links between air quality and health. The data relating to perceptions of air quality were combined with data from another survey of 280 households conducted the previous year, in the Marston Vale, a rural area to the south west of Bedford which has been historically associated with the brickmaking industry, and currently has several landfill sites.

Background: Sources of air pollution

The Borough of Bedford was first defined in the local government reorganization of 1974 and covers an area of 11,595 acres, taking in the area of Bedford, Kempston and 43 rural parishes. The overall population is 137,000 of which 92,000 are resident in the urban areas of Bedford and Kempston. The Borough is defined as a semi-urban environment.

Bedford is located to the north and west of London (45 miles) and lies south-east of Birmingham (65 miles). The city is also in close proximity to to major north-south routes, the M1 (10 miles) and the A1 (6 miles). To the south and east are the M25 (London orbital motorway) and M11 motorway (see figure 7).

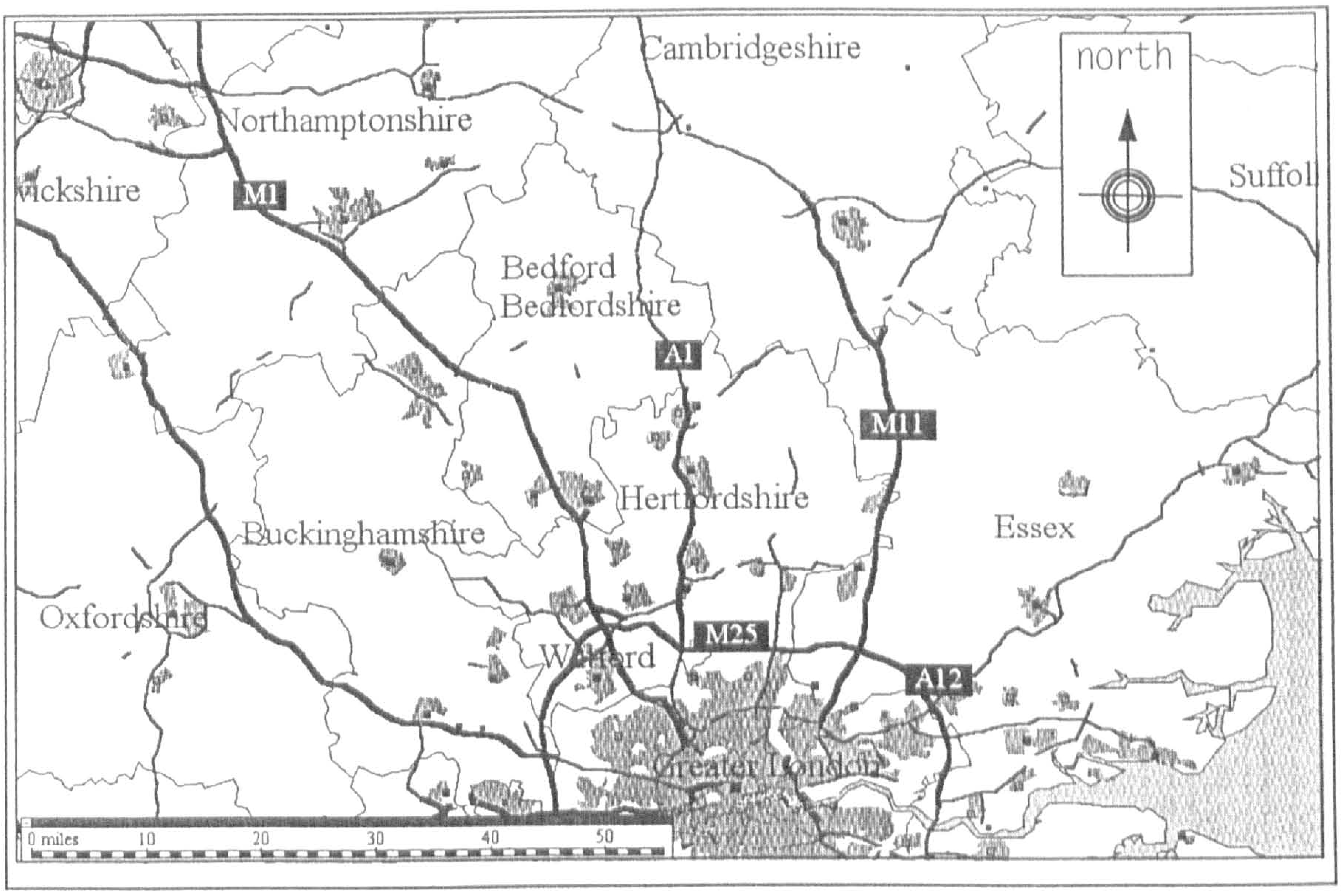

Figure 6: The South/Central region of England

Over the last few years there has been a growing concern over the ambient levels of tropospheric ozone in the Borough of Bedford (Bedfordshire on Sunday 1994, Sweeny 1993, Bedford Borough Council 1995).

Indeed a report commissioned by Bedford Borough council between the 7th June 1993 and 10th September 1993 (Sweeny 1993) noted an early season peak in ambient ozone concentration (171 ppb, 8/06/93). This is well above the threshold capable of causing short term reduction in lung function (see section 2). Furthermore there were numerous cases during this period where EC threshold limits where exceeded and DoE "poor" criteria where achieved. Results for 1994 indicate that five "ozone episodes" occurred during the period of measurement (June-August), with a maximum of 127 ppb, which was the highest hourly average concentration measured in the UK. Bedford also recorded the highest values in the previous studies in 1992 and 1993, and meteorological analysis indicates that winds from the south east were associated with the highest concentrations.

A number of health guidelines were exceeded during the measurement period, including WHO hourly average, 8 hour and daily mean criteria, EC Directive Population Information and Health Protection Thresholds.

While Bedford was found to have tropospheric ozone levels lower than most rural areas, the levels recorded where high for urban areas and where higher than any of the other 17 national ozone monitoring sites for the study period.

In light of these findings it may be proposed that Bedford's tropospheric ozone levels represent a significant health risk due to the concentration levels experienced in this area as well as the relatively high population density. Under this regime it is likely that Bedford would qualify as an "Air Management Area" under the 1990

Environmental Act (DoE 1995b) Air quality management in the Bedfordshire and Hertfordshire region.

While ozone is clearly a significant problem for Bedford Borough, the causes of the problem may be located outside the boundaries of the local authority. In 1994 for SO_2 and fluorine currently carried out by the two authorities affected.

Land fill sites (again, particularly in the Marston Vale) give rise to methane and odour nuisance, although this is generally considered more as a contaminated land problem, thirteen local authorities in the surrounding counties of Bedfordshire and Hertfordshire commissioned a study into the feasibility of a joint strategy for the region as a whole.

The Herts and Beds region contains a balance of urban and rural areas, but comparatively little in the way of polluting industry, relative to the density of population. Those industrial sources of air pollution which do occur within the region are considered to be adequately controlled by effective implementation of the current legislation (Environmental Protection Act, 1990),

In the past, the brickworks in the Marston Vale have given cause for concern in the north western part of the region. However, as the industry has been declining, it is no longer considered to be a major problem, a view reinforced by the results of monitoring, rather than an ambient air quality problem.

Traffic is overwhelmingly the main source of air pollution which concerns the authorities involved in the survey. It was mentioned by all authorities as the single most important source of ambient air pollution in their districts.

The main routes through the region include two major national north-south routes, the M1 and A1(M), and the London orbital motorway, the M25. The combined corridors of these motorways cover a considerable proportion of both the land area and the resident population of the region.

In addition to the main through routes, there is widespread concern about traffic pollution in the main urban centres, where levels are likely to be high because of traffic congestion, and large numbers of people are exposed.

In more rural parts of the region, (North and Mid Bedfrodshire and East Hertfordshire), secondary production of ozone, from the action of sunlight on nitrogen oxides in the presence of VOCs, is more likely to be a significant problem. Ozone levels are also likely to be affected by the migration of pollutants from outside the region, particularly from London.

The significance of ozone pollution to the region is borne out by the ozone monitoring carried out by Warren Springs Laboratory (now NETCEN) on behalf of Bedford Borough Council during the summers of 1992, 1993 and 1994.

Variations in approaches to air quality monitoring in the region

At present, ambient air quality monitoring at local authority level is not a statutory duty. Under the 1990 Environmental Protection Act, local authorities have the power to write authorizations for prescribed processes in order to ensure monitoring and compliance, but there is no specific requirement to carry out any additional air quality monitoring. Any monitoring of ambient air quality is thus at the discretion of the individual authorities, and the survey revealed little consistency in approaches to air quality monitoring across the districts, except in the recognition of traffic as being the main problem, and concern about potential impact on human health.

In addition, organizational structures, are not consistent as between different authorities. Whereas some authorities had special departments and dedicated staff with responsibility for air quality monitoring, in others monitoring was a minor aspect of work, carried out on a part-time basis by staff whose major commitment was in other areas. In many cases, monitoring work was being carried out by staff whose main commitment was to answering and investigating noise and other nuisance complaints by members of the public. This work, being both reactive an a statutory requirement, took precedence, leaving little time over for monitoring work. Not surprisingly, levels of expertise and staff morale varied widely, with high staff turnover, and a consequent lack of continuity, being a common problem.

In any authority, monitoring work has to compete with other environmental health work for resources which are allocated as part of a budgetary process in which, in turn, environmental health also has to compete with other departments. Differences in commitment to monitoring in the different districts are thus related to the priority accorded to monitoring relative to other competing requirements, and to the political and economic conditions of the districts..

Although budgetary constraints are important, levels of commitment appear to relate more to political will than to financial considerations. Although in some cases, all the initiative for monitoring had come from officers, in others, monitoring had been introduced in response to concern by elected councilors or members of the public. Recent political changes following the May 94 Local Government Elections were cited by respondents in some districts as having led to an increase in interest on the part of members.

Practical implications of a regional strategy

Because of the trans-boundary nature of air pollution, all districts are subject to influences from outside their own area and there is little value in individual districts monitoring in isolation. Pollution may be regarded as a regional, national or even international problem, rather than one which an individual local authority has the power to do something about. A regional strategy is needed in order to take into account, and also to measure, the geographical dispersal of pollutants

However, despite widespread recognition of the value of a regional strategy, there was also considerable cynicism about the political viability of authorities pooling resources for a regional benefit. Different authorities face different constraints, and different priorities. In some authorities, air quality was seen as basically good, so that there was no perceived need for monitoring. Different priorities in the different districts, dictated partly by different perceptions of the nature of the problem locally, lead to differences in willingness to commit resources. This is exacerbated by the fact that pollution generated in one district may only become a problem elsewhere, so that the authority in the originating district has no incentive to tackle the problem, while the authority in the receiving district is powerless to do anything about it. Local priorities are affected by factors outside of those directly affecting air quality management, including local politics.

In addition, environmental health departments have no control or remit over the main causes of pollution, even in their own area. While individual local authorities may have some control over traffic management in their own town centres, there is no regional body which has responsibility for the motorways and trunk roads which pass through Beds and Herts, not to mention the migration of traffic pollution from outside the region. National transport policy, particularly with respect to road building and motorway widening, is crucial to air quality.

Local government re-organization is also likely to have an impact on the region, changing the status and the balance of urban and rural areas within some districts, and producing an atmosphere of uncertainty about the future which was apparent in several interviews.

In summary, despite sound scientific and management reasons for strategic regional management of air quality, differences in perception between the different constituent authorities suggest the potential for considerable difficulties in developing and implementing such a strategy.

Relationship between the local authorities and the public

Growing levels of public awareness and concern, and the need to be able to provide both real-time health warnings and general information about local conditions, (even if only to reassure residents that conditions are good) were cited most frequently as reasons for monitoring.

However, this was also widely seen as a weakness in present systems, whether because the information is not timely enough (real-time monitoring is required for health warnings), because of the scientific uncertainties involved in relating pollution data and health data, or because of the time and effort involved in providing meaningful information to the public.

The success of a strategy of providing health warnings depends crucially on the public's awareness of sources of information, on their perceived relevance, and on the ability of the individuals to respond by changing their behaviour. Public perceptions of air quality are therefore of great importance, in addition to the question of providing a democratic mandate to the local authority to act on the public's behalf. However, the issues of differences in perception between the regional and district levels becomes even more apparent when attention shifts from the district down to communities and individuals.

Individual perceptions

The second piece of work to be discussed here combines the results of two studies, one carried out in 1993 in 8 rural communities in the Marston Vale, and one in 1994 in 6 areas of the Bedford urban area and three outlying villages. Respondents in both studies were asked to evaluate local air quality on a scale of 1 to 5, and to state what they considered to be the three main influences on air quality locally. In the 1994 study, respondents were also asked questions about their concerns with regard to health, and about their awareness of sources of information on air pollution.

Importance of air pollution relative to other health worries

Respondents were asked to list up to three issues in response to the question *"Which issues related to your own or your family's health are you most concerned about?"*. The most frequent response (other than "none"), mentioned by 37 respondents (12.5%), was air pollution. It was mentioned by 26 respondents (9%) as their most important concern .

The relative importance of pollution as a health issue may be due in part to considerable publicity in the media about ozone pollution during the period of the survey . The number of respondents mentioning pollution as an issue reached a peak on 6th July (45%)and then fell away (never reaching more than 16% after 16th July), while awareness of media reports about air quality (measured by respondent mentioning at least one media item) rose over the period to a peak of 100% on 27th July, then fell back to 65-70% for rest of period (Figures 4 and 5).

This may suggest that, while awareness of air quality issues continued to rise over the period, the main impact on health concerns was caused by coverage of pollution incidents at the start of the period, and that over time, other issues came back into the forefront of concern.

Information on air quality

Respondents were asked whether they had ever tried to find out more information about air quality, whether they would like more information about air quality, and if so, where they would look. Ten respondents (3%) said they had tried to find out more, but none had asked the Environmental Health Department. One hundred and sixty respondents (53%) said they would like more information, of whom 14 (5%) said they would ask the Environmental Health Department, and another 15 (5%) said they would ask "the Council".

One hundred and thirty two respondents (44%) were aware of at least one item in the media concerning air quality, of which 48% referred to TV, 22% to national press, 12% national radio, 6% local radio, 5% magazines and 4% local press.

Perceptions about local influences on air quality

When the data were analyzed on an area by area basis, significant differences were apparent between the different areas. Predictably, communities close to the landfill sites were more concerned about them than those further away, and respondents in the villages were more concerned about agricultural pollutants, sprays and pollens, than those in the urban area. However, there were some surprising results, such as the fact that residents in Willington, a rural village some 11 kms from the brickworks showed a higher degree of concern than those in Kempston, only half the distance away.

When the responses were plotted in relation to distance from the source mentioned, a distinctive pattern emerged. For each community, responses could be divided between those which were relatively close (within .5kms - 55% of all responses) and those relatively distant. This pattern was repeated in the case of all the communities involved, and inspection of the responses showed that the "more distant" responses in all cases corresponded to the brickworks/landfill area of the Marston Vale.

In general, sources mentioned could be divided into:

- immediate / diffuse sources, e.g. traffic, domestic heating;
- locally significant point sources, e.g. the crematorium in one area, the sewage works in another
- major regional point sources, i.e. brickworks and landfill

In evaluating local air quality, respondents frequently drew comparisons with other areas, or other times, for example with comments such as "it's better here than in the town"; "I used to live in London, and its much worse there", and "it's been better since the brickworks closed down." Such comments suggest that relative perception of air quality is important.

Perceptions of local air quality are clearly the result of a complex interaction between local and regional factors, personal experience, local knowledge and information and understanding about pollution sources. Some of those issues which are of greatest concern to residents are not even seen as issues of air quality by the district authorities, for example, landfill and agricultural emissions, neither of which fit into the institutional structure of air quality management..

Conclusions

Regional management of tropospheric ozone is fraught with difficulties within a fragmented framework. Air quality standards are set at national level and do not take into account local conditions and air flows. Pollution control standards in major urban areas have the aim of improving air quality in that area. Monitoring and control of that air quality remains the role of local authority.

The local authorities however, are caught between two levels. On the one hand, they recognize the need for regional, national, and potentially even international management of issues of air quality which are affected by factors which lie both geographically and institutionally beyond their control. On the other hand, they are directly accountable to the residents in their districts, whose concerns and perceptions are more likely to be affected by what occurs in "their own back yard", and who expect "the council" to deliver acceptable air quality on this basis and on their own terms. There is very little scope within the planning process for local government in rural areas to influence air quality policy in urban conurbation's who are faced with immediate local problems of there own. Especially if the policy needed may be seen to worsen the problem in the locality responsible for it.

The counter intuitive approach needed for ozone control at a distant location is in contradiction with the more immediate local air quality problems. If abatement measures are to be taken on a local level they must not only achieved perceived benefits for that population but they must be relevant within the context of the region as a whole (Stern 1992). Studies aimed at devising air quality management strategies need to be able to fully assess the situation in terms of both an overall regional picture of the cause and effects of the pollution episodes as well as the social context in which it sits. In the absence of such an approach it is likely that air quality strategies will continue to develop in such a way that they approach the wrong problem at the wrong level increasing the number of quotes such as those found at the beginning of this text.

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Divergent Evolution Of Life-Styles And Institutions: The Need For Socially Responsive Air Quality Management

Cannibal G & Hadfield L (1997)[2]

ABSTRACT

The management of air pollution has a long and complicated history in the UK. Over the centuries, the issues of concern have changed, as policy-makers have struggled to deal with the often contradictory needs of human health and life-styles within a context dictated by pre-existing conditions and institutions. As old problems are "solved", new ones emerge to replace them, resulting in legislation which must constantly react to unforeseen problems after they have become damaging.

Within the context of modern air quality management, the behaviour causing the pollution has shifted from one directed at economic gain in limited locations - manufacturing industry - to one aimed at increasing flexibility in individual life-styles through the use of ever cheaper and more available private transport. Recent policy for managing road transport derived air pollution however, still relies on the tried and tested approach of locally oriented economic incentives based on the promotion of methods originally developed in the Alkali Acts of the nineteenth century and the Clean Air Acts of the 1950s.

Using data from research into perceived utility derived from the use and ownership of the motorcar, the paper shows how the management systems for controlling pollution have now diverged from the social systems responsible for generating it. The paper concludes by suggesting the need for an approach to legislation that shifts the emphasis from the present sector-led reactive management to a more flexible and proactive approach capable of responding to issues as and when they occur.

INTRODUCTION

The problem of air pollution from motor transport seems to be a very modern one. Concern about the relationship between poor air quality and its impact on human health has grown rapidly in recent years, as indicated by the growth of legislation in the UK (1995 Environment Act (DoE, 1995) and UK National Air Quality Strategy (DoE, 1996), US (Calvert et al, 1993) and EU (Commission for the European Communities 1994).

However, air pollution, and government attempts at regulating it, are not new phenomena. Consideration of the history of air pollution and its management in the UK over the last two centuries indicates a process of evolutionary development in which physical changes to the composition of the atmosphere become recognised within an environment of controversy and dialogue, leading to policies which are embedded within the contemporary culture and institutional arrangements. In turn, the outcomes of those policies, the institutions through

[2] Cannibal, G. L. and Hadfield. L. (1997). *Divergent Evolution of Life-Styles and Institutions: The Need for Socially Responsive Air Quality Management.* in Kanteralis and Hickey: *Our Natural Environment at a Cross-roads:* Proceedings of the 3rd International Conference on the Environment, Cambridge MA, USA, IEA.

which they are implemented and the effects which they have on the behaviour of individuals, feed back into the physical system, and provide the context for the next "problem".

Thus, although the main cause of pollution in most major urban areas of the UK is the wide ranging use of the motor car (Air Health Strategy 1996a ; Air Health Strategy 1996b), the structure of the institutions and policy approaches within which it is being managed are inherited from the past, and bear the fossil imprints of past problems. Traffic pollution differs fundamentally from the pollution sources which those polices were developed to manage, being a non point source originating from a common behaviour of people in modern society, which produces a wide range of both primary and secondary pollutants capable of migrating across traditional administrative boundaries.

The application of the traditional technological fix and financial stick and carrot approaches has been of little success in coping with these new problems. In some metropolitan areas, management plans to reduce road transport derived air pollution have been in existence for over two decades in both the United States (Chameides 1993; Huess and Wolffe 1993) and the UK (Air Health Strategy 1996b), but have, as of yet, in spite of great effort and cost, produced little significant benefit in terms of air quality.

The present paper will illustrate how the evolution of institutional culture in air quality management constrains air quality policy, and that these constraints restrict the ability of modern society to deal with present air quality problems. The paper will begin by looking at the history of air quality management in the UK and the institutions and approaches to which it has given rise, focusing specifically on certain aspects, i.e. the Alkali Acts of the nineteenth century and the Clean Air Acts of the 1950s, in order to show the ways in which air pollution problems, perceptions of them and responses to them have co-evolved over time. The paper will then consider current policy, as embodied in the 1995 Environment Act and Air Quality Strategy, to demonstrate the influence which historical institutions have on current policy. Using survey data on individuals' reasons for using private transport, the paper will conclude by demonstrating that there is a mismatch between the institutions inherited from that history and the needs of current day air pollution problems.

A BRIEF HISTORY OF AIR QUALITY MANAGEMENT IN THE UK

The industrial revolution of the late 18th and early 19th centuries led to a significant deterioration of air quality in Britain, particularly over the larger towns, but air pollution had been a cause of concern for many centuries previously, and as early as 1273, the burning of sea coal was prohibited in London on the basis of being prejudicial to health (Ratcliffe, 1992). By the early years of the nineteenth century, the rise of manufacturing industry, and particularly the burning of coal to produce steam power, was taking its toll on the quality of air over the major English industrial cities. However, the consensus of the time was that pollution, far from being a problem to be tackled, was an inevitable outcome, and indeed a visible symbol, of economic growth and prosperity (Wohl, 1983).

Those individuals brave enough to suggest that "something should be done" faced a barrage of opposition and counter argument. The first of many such concerned individuals was Michael Angelo Taylor, MP for Durham city, who first raised the issue in parliament in 1819. His efforts led, in 1821, to the passing of a bill requiring furnaces of steam engines to consume their own smoke (Brimblecombe, 1987). The bill was a feeble affair, which had been severely weakened in debate, and it was never put to the test in the courts, but initiated the process of changing the climate of the opinion (Ashby & Anderson, 1981).

Nevertheless, arguably the greatest significance of Taylor's bill was that it spurred the industrialists into action to defend their interests against what was seen as unwarrantable interference from the state. Although the technology to enable steam engines to burn coal more efficiently, and hence reduce the amount of smoke produced, was already in existence, in the absence of any regulation or incentives, the industrialists were not prepared to adopt it.

Apart from the objections of the industrialists (and their representatives in parliament) to any suggestion that the state might be permitted to interfere with the running of their businesses, other main arguments were employed. Firstly, it was said that it was not possible to provide conclusive evidence that smoke was a hazard to health, as many other factors, such as malnutrition, poverty and long hours of work exacerbated the symptoms of respiratory disease. Secondly, problems existed with the technology designed to improve fuel consumption.

The one industry for which significant legislation was achieved was the alkali industry. The first of a series of Alkali Acts, passed in 1863, led to the setting up of the Alkali Board. Wohl argues that one reason for the successful implementation of the Alkali Acts was that alkali pollution was subject to accurate chemical measurement, Additionally, the main impact of alkali pollution was seen as being on the value of land in the vicinity, rather than the public health, so that two major vested interests, those of the industrialists and the landed gentry, were pitched against each other (Wohl, 1983). However, the main reason for its success was the fact that the balance of evidence in the economic argument was tipped in favour of pollution control when industrialists realised that pollution control itself could be a source of economic growth, and that associated technological innovations could result in industrial profits (Wohl, 1983).

The approach taken by the first Chief Inspector of the Alkali Board, Angus Smith, along with four sub-inspectors, was to work closely with the industrialists to convince them that improved pollution control was in their own economic interests. This established a culture of professional and centralised inspection which has continued to the present day, and provided a role for qualified scientific experts, such that, as Wohl points out, by 1876 most alkali works were employing their own chemists to help them comply with the acts and to find profitable uses for their waste products.

However, the Act was very narrow in its scope, applying only to the emission of hydrochloric acid, and only from alkali works. Despite a growth in the number of nuisance complaints made to the Inspectorate, and the efforts of the chief inspector, Angus Smith, no extension of the powers was included in the 1868 Alkali Act Perpetuation Act, which confirmed the continued existence of the Inspectorate after the end of the initial five year period, or in the Alkali Act of 1874.

The 1874 Act did, however, introduce the following significant clause:

> *"the owner of every alkali work shall use the best practicable means of preventing the discharge into the atmosphere of all other noxious gases arising from such work, or of rendering such gases harmless when discharged"*

The use of "best practicable means" was first introduced in the Leeds Improvement Act of 1842, since when it had mainly been seen as a legal defense for polluters (Ashby & Anderson, 1981). However, in the hands of Smith and his inspectors, another interpretation was put upon it. A major problem with the extension of the Alkali Act's powers to other industries lay in the technical difficulties inherent in defining fixed emission standards for all gases and processes. The adoption of the "best practicable means" formula provided a means of imposing some control standards even where fixed limits could not be applied, and has been defined as follows:

> *"emissions in terms of both concentration and mass, had to be reduced to the lowest practicable amount taking into local conditions and circumstances, the current state of knowledge and control technology and effects of substance emitted, financial considerations, and the means to be employed." (NSCA, 1996).*

The development of the UK approach to air quality management during the 19th century can be seen as having established a split between centralised control and inspection of "noxious emissions" and local management of smoke, and a professional inspectorate, working in co-operation with the manufacturers in order to improve pollution control, and employing the flexible formula of "best practicable means". However, perhaps more significant was a slow, but steady, shift in public opinion, amid fierce debate, towards the assumption that air quality is a public good which can, and should, be subject to legislative control.

THE GREAT SMOG AND THE CLEAN AIR ACT OF 1956

Following the Alkali Acts, procedures, however limited, were at least put in place for the management of industrial emissions. A far more taxing problem, however, was the issue of domestic smoke production. Although the problem of smoke from coal fires had been recognised for some time, and potential solutions in the form of improved domestic stoves were technologically feasible, it was perceived that control would present severe political problems. Just as emissions from factories, as discussed earlier, were seen as a symbol of prosperity and source of national pride, so the "cheery open fire" was regarded as the focus of English family life, with which no politician would dare to interfere (Ashby & Anderson, 1981).

The introduction of legislation had to wait until the middle of the next century, when a combination of factors created a more suitable climate for change. The dense fog which enveloped London from the 5th to the 9th December 1952, to which four thousand deaths were eventually attributed, is credited with being the trigger which precipitated the 1956 Clean Air Act, through whose provisions local authorities were empowered to declare part or all of their district a 'smoke control area'. However, implementation varied greatly between different areas. While progress in Greater London was so significant that it was claimed in 1975 that there had been no smogs since 1962, local authorities in coal mining areas were, in the 1960s, more concerned with the mining interests and the future of the industry in their areas (Hall, et al, 1975). Nevertheless, the 1956 Clean Air Act is regarded as having been successful in reducing smoke and smog. Perhaps some of the improvement in terms of air quality may, however, be attributable to technological changes which were taking place in parallel, such as the discovery of natural gas in the North Sea, the development of nuclear power, and the phasing out of steam locomotion. Ironically, this last development has been overtaken by the growth in motor transport, leading to the current stage in the evolution of air quality issues.

The main outcome of the Clean Air Acts was to define air quality management as a local authority responsibility, and to establish the approach of promoting the uptake of technological change through the use of financial incentives and disincentives, such as the provision of home improvement grants for the installation of domestic central heating systems, and fines for the burning of traditional fuels (Ashby & Anderson, 1981).

CURRENT APPROACHES

The management structures set up under the Alkali Acts continue to influence the management of pollution from industrial processes. Under the Environmental Protection Act of 1990, a framework for a system of integrated pollution control was established, by means of which control of pollution from industrial processes was divided between the local authorities and the centrally controlled pollution inspectorate, Her Majesty's Inspectorate of Pollution (HMIP) (NSCA, 1994). Releases of pollution to the air by all prescribed processes were to be minimised by means of Best Available Techniques Not Entailing Excessive Cost (BATNEEC), a direct descendent of the Best Practicable Means (BPM) formula adopted by the Alkali Board in 1874.

However, successful though the integrated pollution control approach may be (NSCA, 1996), in terms of air quality management, it can be seen to be directed at the wrong target. Industrial sources are no longer the major sources of pollution in the UK; motor vehicles are (QUARG, 1993; DoE, 1996). The air pollution problems facing environmental managers today are fundamentally different from those of the previous two centuries. A much wider range of pollutants that are not confined within jurisdictional boundaries is involved, where the air quality at the source of the pollutant is often different both quantitatively and qualitatively from that at the area of impact (Hadfield & Cannibal, 1996). Furthermore, the main cause of pollution is no longer a single activity whose main aim is direct profit maximisation (such as manufacturing), nor is it a locally confined technical problem where an accessible and cost effective alternative to the problem is available (as was the case for domestic heating).

The government response to these issues, spurred by increasing recognition of the nature of the problem and the involvement of the European Union in environmental legislation, is embodied in Part IV of the 1995 Environment Act and the UK Air Quality Strategy Consultation document. The overall aim of the Act has been described as establishing a framework for standards for those pollutants which are of most concern, mainly those identified in the EU Directive on Ambient Air Quality Assessment and Management (Commission for the European Communities, 1994). The general approach of the Act is typical of those introduced in the last few years from both the UK and European legislators in that it approaches air quality from the perspective of standards for individual pollutants based on probable health effects (DoE, 1995), and to a large extent places the burden of ensuring that air quality targets are met on local authorities.

The Act requires local authorities to carry out a review of local air quality; to assess whether air quality standards or objectives are being achieved; to designate "air quality management areas" (AQMA) if necessary; and to draw up management plans for policies to meet standards. AQMAs can be seen as the direct successors of the smokeless zones set up under the Clean Air Acts of the 1950s. However, the Act provides no guidance to local authorities as to how this is to be achieved, other than through the adoption of technical fixes such as the catalytic converter. Just as major improvements were achieved through the introduction of smokeless zones and adoption of new technologies for domestic heating, it is thought by the Department of the Environment that new fuel and engine technologies can be employed to tackle the problems generated by motor vehicle pollution (DoE, 1996).

The Need for Behavioural Change

Current UK air quality policy can thus be seen as being based firmly within a context of existing tried and tested approaches and institutional structures. Industrial emissions are to be controlled by inspection carried out jointly by a centralised Inspectorate and local authorities using BATNEEC for specific processes, while air quality management areas are to be created in order to tackle the more general problem of improving ambient air quality. However, ambient air quality is the emergent outcome of underlying processes, involving both the traditional industrial emissions, and (more significantly in the contemporary UK) mobile, traffic generated emissions, and as such, is not amenable to direct management (Hadfield, 1997). In attempting to affect the underlying processes which give rise to these air pollution problems, the approaches available can be characterised as: changing the technology (technical fix approach) e.g. through the introduction of catalytic converters; and changing the behaviour.

The technical fix approach has been widely criticised because of the tendency of new technologies, such as the catalytic converter, to bring new, unanticipated, emergent problems in their train (Sperling, 1984). More significantly perhaps, as was pointed out by the Royal Commission on Environmental Pollution in its Eighteenth Report, and as has also been acknowledged by the Department of the Environment, the projected growth in motor traffic is likely to invalidate any potential benefits to be gained (RCEP, 1994; QUARG, 1993; DoE, 1995):

> *"... the aim of future planning policies must be to reduce the need for movement (instead of stimulating ever more mobility, as has for too long been the case). This will involve a gradual shift away from lifestyles which depend on high mobility and intensive use of cars".* (RCEP, 1994).

This problem is heightened when one considers that the anticipated effect that the catalytic converter has on automobile emissions may have been overstated in the first place (Air Health Strategy, 1996; Air Health Strategy, 1997).

The approach embodied in the UK Air Quality Strategy (DoE, 1996) relies on both of these aspects, with Chapter 6 concentrating on technological improvements and Chapter 7 on encouraging voluntary measures and promoting individual commitment to air quality. While local authorities are encouraged to draw up integrated plans for managing air quality through the 1995 Environment Act, national policies are essentially oriented around improving the technology of emission control, by increasing fuel standards and the application of BATNEEC to industry, and imposing financial disincentives on the car driver.

The concept of BPM can be seen in the stated aim that environmental impacts are to be reduced through emission controls and set methods to control the quantity and growth of road transport in particularly sensitive areas, with due regard to be given to the economic costs and benefits of individual measures. The measures to be taken in order to achieve these ends are four-fold (DoE, 1996):

1) Improvements in vehicle technology, seen as the main contribution to improving air quality, in line with the principle of cost effectiveness.

2) Closer control of vehicle fleets, including tighter emission standards and stricter enforcement of standards.

3) Development of "environment responsibilities" by fleet operators and the by the public at large. These include the introduction of an annual increase in road tax (5%) to place more of the real environmental cost onto the consumer, the promotion of greener motoring, and new powers for local authorities to restrict or discourage private transport use by restrictions on parking space and the closure of roads to motorised traffic.

4) Long-term infrastructural changes in planning and transport policies to reduce both the need to travel and reliance on the motor-car.

Further roles for central government are introduced as the "education of the public" and the need to "encourage debate in this area". Changing the behaviour of the public in terms of their usage of the motor vehicle is seen as an essential part of air quality management (QUARG, 1993; DoE, 1996; Longhurst, 1996), and considerable emphasis is placed on this as a strategy, as stated in the government's White Paper, "Air Quality: Meeting the Challenge", published in 1995:

> *"The Government has .. reviewed its public information arrangements in the light of its proposals for a new framework of air quality standards... The key aims of the proposals are to make air quality information as accessible as possible to the public; to provide a consistent framework for describing levels of air pollution, related directly to the new standards, and to action which members of the public may be advised to take; and to promote provision of local air quality information to reinforce local air quality management.*
>
> *An important part of the Government information service is provision of advice at different levels of pollution, and in particular, when air quality becomes 'poor' or 'very poor' according to the current system. ... The Government will be considering how to improve the effectiveness of information, to target advice and to encourage more people to take appropriate action in episodes." (DoE, 1995, Part Six: Monitoring and Public Information, p30.)*

However, questions arise as to the effectiveness of information strategies and financial disincentives in changing driver behaviour, especially when one considers that research carried out on public perceptions of local air quality suggests a low level of awareness of air quality information provided by local authorities (Hadfield, 1997). In order for such a strategy to be effective, the issue must be both understandable and relevant to the individuals whose behaviour is to be targeted. The strategy must appeal to the issues and values important in the recipients life (Ahuja, 1996, North 1984). Consequently, one must consider air pollution issues in terms of the behaviour that cause the problem, i.e. driving.

The car as a feature of the urban compound.

In the 1960s, the car was described as an "article of dress without which we feel uncertain, unclad and incomplete in the urban compound" (McLuhan, 1964). Over the last thirty years, the role of the car has grown even more significant, such that it has become a central part of daily life, generally perceived as necessary for people to carry out employment, maintain social and family contacts and live in ever more dispersed patterns (Wagener, 1993). The car is more than just a feature of urban living, it has been (and continues to be) a major formative aspect of the way in which we live.

The relative merits people place on clean air compared with the actions they undertake that contribute to the pollution need to be known and monitored. To expect people to change voluntarily their employment, the place they live, their way of life and feelings of security for an improvement in air quality (which incidentally is stated by central government not to be a serious threat to the health of the average individual) seems optimistic.

Using data collected during 1996 from on street questionnaires in the south and central region of the United Kingdom, this paper argues that the main reason for a lack of success in air quality management is that the major cause of modern air pollution problems (i.e. the use of the private motor car (DoE, 1995; Air Health Strategy 1996a; DoE, 1996)) is fundamentally different in nature from that of previous air pollution problems. It is the emergent outcome of a derived behavioural problem, where economic considerations are of minor importance in influencing that behaviour and where any costs to the individual from this behaviour are both discrete and highly uncertain (Sperling, 1984). This behaviour is both derived from and contributes to changes in modern patterns of living, working and resting and is becoming increasingly important for the well-being of the individual in modern society (Taylor 1990; Wagener, 1993).

When a group of people were asked at random on the street, whether they preferred to use their private car or public transport an overwhelming 89% said they preferred private transport (see Figure 1). Of the remaining 11% of respondents, 3% didn't know and 8% said they preferred public transport. This result was taken to indicate that the present service provided by the (now privatised) public transport sector is not, within the agenda of the general public, at all satisfactory. This conclusion is supported when one considers that of the respondents who said they preferred public transport, one third also indicated that they use private transport regularly (at least once a day) because public transport is not practical as part of their everyday life, a sentiment illustrated by the following quote:

> *"No I have always preferred public transport to private when it is efficient. Currently however public transport takes too long: two hours rather than forty minutes. My company car and petrol are free."*

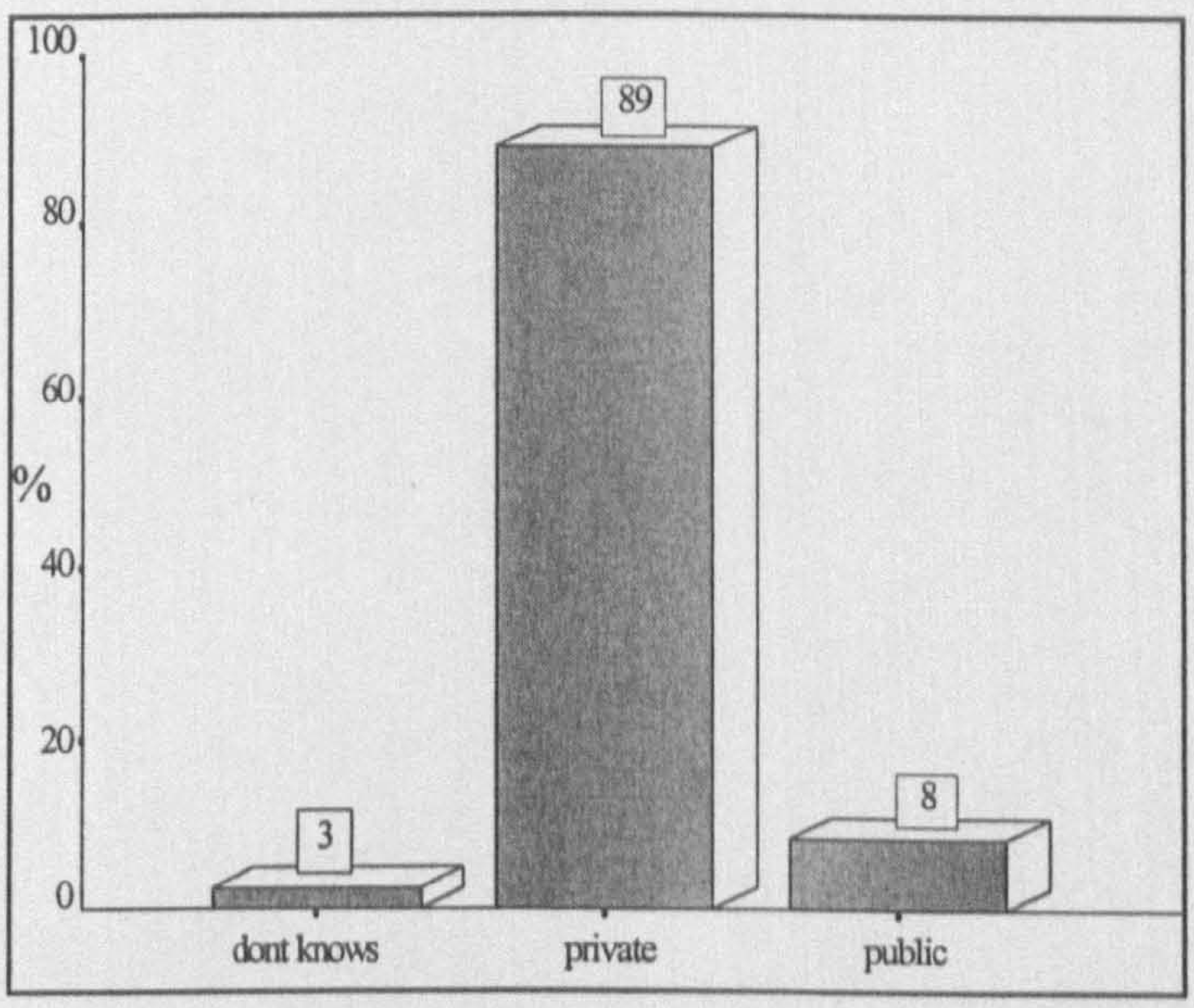

Figure 1: Responses to the question "do you prefer private transport to public"

Respondents were also asked why they used private transport, and the responses were separated into two categories, the first of which was what they used private transport for:

What Do People Use Private Transport For?

Figure 2 shows a summary of the purposes for which respondents felt they needed to use private transport. The majority of respondents expressed a need to use private transport to get from home to work. However, a large minority also expressed dependency on private transport for shopping and maintaining social contacts as well as transporting children to school, especially among female respondents (Figure 2b).

The need for private transport to carry out these tasks was expressed by, for example, the

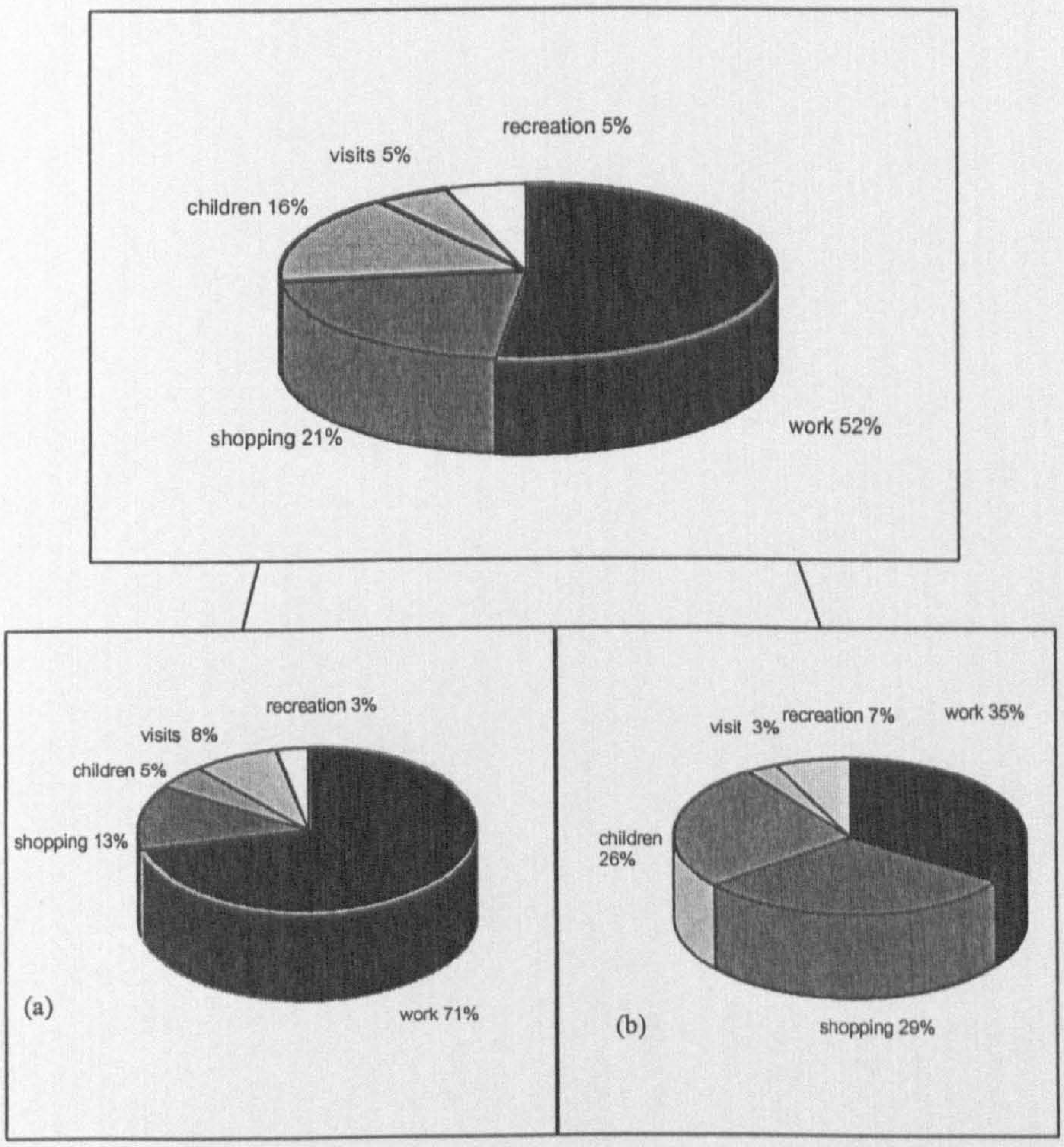

Figure 2: Statements of why surveyed people drive

a) responses from males b) responses from females

following quotes:

> *"I prefer private transport because of the comfort convenience and load carrying capability. for example living in Leagrave and working or shopping in Milton Keynes would be impossible without a car"*

> *"I need it (private transport) for work. public transport would require over two hours more on every working day."*

"Yes impractical to collect children by bus, are at separate schools at nearly the same time."

These results show that the most basic aspects of modern life are dependent upon the use of the private motor vehicle as far as a large majority of the population is concerned. Indeed, this is not surprising when one considers the rapid growth in ownership of the private motor car which is both a cause and reflection of this.

In view of this predominance of the use of the motor-car in fulfilling the needs of most of the population when carrying out the functions of everyday life, any management plan aimed at limiting the use of the motor-car must identify alternatives which are both applicable to these needs and acceptable to the population. In a pluralistic environment the lack of applicability and acceptability to the general population would be both politically risky and potentially counter-productive to the aim of improving the local environment (O'Riorden 1996) as is illustrated by the following quote from a local authority engineer:

"Counties now have new powers to restrict peak area traffic for instance in a case where there is high pollution levels - but this will result in them screwing up their town's economies - people would just go to Milton Keynes."

At best, inapplicable alternatives will result in a general societal consensus that reducing the use of private transport is something that "people" in general should do, but that the individual does not (Arcury and Christianson 1992).

In order to supply a viable alternative which is sensitive to the value that the population places on an activity, a central feature of any policy response must be to identify and understand the way in which people's needs are currently met (Ahuja 1996; Bate, 1994). Thus, one needs to consider why individuals use private transport for the activities they mentioned.

Why Do You Prefer Private Transport?

Respondents who expressed a preference for using private transport (including the ones who replied no to this question but felt they had to use it anyway) were asked to describe in their own words why they felt that this was important, and also to rate a set of pre-determined functions of well being on a scale of 1 to 5. The results are shown in Figure 3.

When one looks at how these needs are expressed, it can be seen that the aspects of well being fall into three groups: high value, medium value and low value.

The first of these groups consists of easy access to a respondent's destination and flexibility (having the transport there at your convenience). These two features are rated much higher than the others (over 4.5 out of 5), and can be considered to be of high importance.

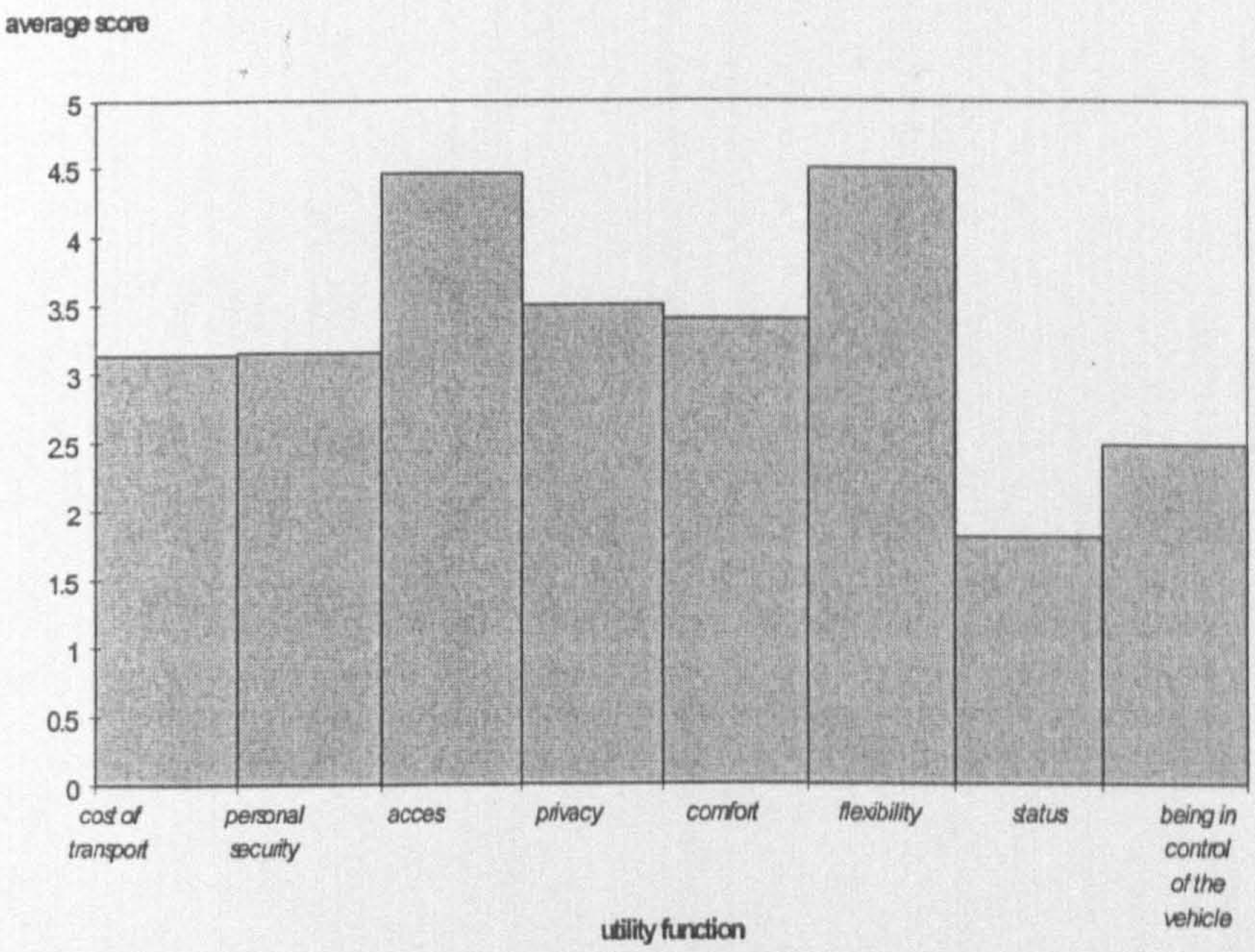

Figure 3: Average score given to pre-defined functions of well being

A second group includes privacy and personal security (rated third and fourth in importance), as well as cost. This, the central feature concentrated on in the UK National Air Quality Strategy, is considered only fifth in the rating of importance, above the final group of "being in control of the vehicle" and "status".

Another feature of these various 'utilities' that car drivers obtain from their use of private transport, is that they are open to variation along geographical, gender, occupational and age related dimensions (Williams et al , 1993). If it could be shown that transport needs and desires do in fact vary in this way, this might have significant implications for the administrative and demographic scale within which policy aimed at wooing car drivers onto other forms of transport is to be defined and implemented. For example, a policy aimed at making public transport cheaper is doomed to failure if the local population prefer private transport due to a perceived problem of personal safety.

The responses from the survey were classified according to the demographic variables of age, gender, economic grading[i] and two spatially related variables of conurbation type and "satisfaction with local public transport" (since public transport provision in the UK varies markedly from one local authority to another). The association between these variables and the values assigned to the utility indicators described above was analysed using one way ANOVA techniques (it had been established that the independent variables were not associated with each other (see Cannibal 1997 forthcoming)). The associations between the demographic variables (age, sex and geographical location) and aspects of personal utility derived from private transport are shown in Table 1.

Table 1 Significant associations between independent and dependent variables.

	sex	age	residency	economic grading	satisfaction with

					public transport
access			√		
comfort		√			
cost		√	√	√	√
control		√			
security	√		√		√
flexibility		√	√		
status					√

The result of the analysis was evidence that the aspects of utility derived from the use of the motor car are associated heavily with the respondent's age and place of residence, as well as the background satisfaction with public transport provisions. The implication is that not only could these aspirations and needs influence the success or failure of policy aimed at minimising the impact of road transport related air pollution but that they also vary within areas covered by the same policy making body. An awareness of this phenomenon is thereby central to the development of suitable and effective policies.

Conclusions

Consideration of the history of air quality management in the UK over the last two centuries shows that institutions and approaches designed to tackle air quality issues have evolved from attempts to control localised point sources from domestic or industrial premises, which were amenable to technological mitigation promoted within a framework of fiscal incentives and regulatory disincentives. Current air quality strategy within the United Kingdom relies more on past and proven approaches than on approaches suited to a whole new breed of problem, that of the over use of the motor-car.

This traditional approach of financial regulation and isolated local management of polluting behaviour is no longer applicable to the major problems facing air quality management. The motor car has come to serve a wide variety of needs for a great many people in every day living. Any management plan aimed at providing an alternative to the reliance on private road transport must be both acceptable and relevant to the target population. In order to do this, alternatives must fulfil similar expectations and desires to those fulfilled currently by the private motor car. Otherwise, such alternatives will be subject to failure and may produce emergent results that are contradictory to the aim of improving the urban environment, for example by driving away potential investment.

The strong emphasis which the UK Air Quality Strategy places on central government fiscal measures, such as increasing national levels of fuel duty and road tax, as a method of changing driver behaviour, can be seen to be inapplicable if there are no alternatives to private transport which meet the needs for flexibility, access, security or comfort (Figure 3)[ii]. This approach, demanding merely a willingness to pay more money to maintain more important aspects of well-being[iii], will be ineffectual until large sections of the population are economically coerced out of driving. This coercion could lead to long term resentment within society (Hardin 1968), essentially alienating the very people on whose co-operation the policy maker depends for the aims of the policy to be met (O'Riorden 1996).

An added complication in managing transport derived air quality problems is that any provision made to provide applicable and acceptable alternatives to the motor car must acknowledge the local variation in the aspects of well being that individuals derive from private transport use. They must be set at a local level through mutual co-operation between the management authority and the population at which that policy is aimed. In the absence of such an approach, voluntary change in such an important activity is unlikely. On the other hand, forced change, by means of financial coercion may have far-reaching implications, such as political disfavour of the implementing authority, public pressure to reduce the value placed on clean air, or avoidance of economic costs through activities such as tax avoidance or illegal parking (essentially encouraging individuals to break the contract on which society is based (North, 1984)).

The worst case scenario which could result from this approach would be the ultimate creation of a society in which opportunities for individual fulfilment are segregated between those who have access to private transport and those who do not.

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[i] a derivative of car type, make and model designed to express the respondent's ability or wish to spend money on private transport.

[ii] especially when one considers that only one person in the entire survey mentioned environmental issues as a concern when deciding over mode of transport.

[iii] especially when one considers the importance of these features in the maintenance of employment or the role they can play in saving money by, for example, allowing cheaper out-of-town shopping.

PAGE

NUMBERING

AS ORIGINAL

Nice Science but What About the People

(G.L. Cannibal: Air Water Waste Management nov 1996, Comment)

How do technical documents from the Quality of Urban Air Review Group (QUARG) become transformed into such shoddy pieces of legislation as Part IV of the Environment Act 1995?

Their most recent report, entitled "Air Borne Particulate Matter in the United Kingdom", is essentially a fairly understandable and comprehensive review of the present knowledge of the technical aspects of airborne particles, covering their properties, monitoring techniques, trends, and impacts. The conclusions are succinctly summarized . Like many publications of its ilk, it stresses the importance of reducing road transport emissions and cross (national) boundary strategies.

The report points out that air borne particles have received relatively little attention as pollutants, since any serious impacts of these pollutants were thought to have been adequately dealt with in the Clean Air Act of the 1950's. However, here they are again posing a problem, and as far as I can see, without any surety of a solution. Which takes me back to my question.

A clue to the answer can be found in the title of the report, restricting emphasis to a particular group of pollutants in a particular place. Although much is said about the relationship between PM_{10} and NO_x , and their high transportation rates, restriction at this stage of the information gathering process has been encouraged by, and encourages, a policy approach that essentially treats modern air pollutants in a way similar to the 1950's. The resultant Act tries to manage regionally and nationally dispersed complex pollutants as discrete local (authority?) problems, based on the concept of individual Air Quality Standards. This approach bears little resemblance to reality where the source and reception of many pollutants often crosses administrative boundaries, whilst the pollutants themselves are subtly interlinked in complex, poorly understood ways.

While this report is comprehensive, the main problem for environmental management is not lack of scientific knowledge but approach. Effects of pollution are still essentially considered of in terms of their direct impacts on human health (a tradition established in the 1800's). In reality we are addressing symptoms of behavioural patterns which damage a part of the environment on which we, as a species, depend not only for our physical health but also our mental well-being.

Indeed, nearly all air pollution related threats to human health in urban areas would to a great extent be solved if another feature of urban well-being, the motor car, could be controlled. Nevertheless, while the Environment Act firmly lays the responsibility for improving air quality on the steps of already besieged local authorities, Downing Street seems to be occupied with other priorities: privatization of public transport and the introduction of ever larger lorries. It is difficult to see how the Act can produce any significant effect.

In the absence of a firm commitment to a more equitable and sustainable agenda, government bodies show a reliance on science for a technical panacea. That this can have disastrous results is demonstrated by the present beef crisis (which incidentally also raises questions about the reliability of international co-operation procedures for long-term control projects).

A new approach to environmental management is needed, one that can influence our national culture as a whole, and is generally acceptable to the individual and the nation alike. This would not only require scientific understanding, but also a deep societal understanding of the causes of the problem and their relation to peoples lives.

Appendix 2: Interviews

PAGE

NUMBERING

AS ORIGINAL

Bedford County Council *3/07/96*

Present G.L. Cannibal, Nick Cotis,
Lee Fitzjohn, - social services
Paul Vann, head of research - planning
Charles Cousins - green space officer environmental manager
(Nick hands out sheets - see attached sheet)

1. **Charles Cousins** - so these are summarise of local authority duties under the 1995 environmental act part IV and your asking us to comment on them.
2. **Nick** Yea, especially on the county council functions, especially the sentence must make representations to the district council' and put forward proposal and time-scale for management and information exchanges as reasonably requested.
3. **Charles Cousins** well I mean the main thing for the County Council to do is to try and look at how its transport planning function can be used to tackle some aspects of the air quality management plan that's been produced. as I understand it there is not a requirement to produce an air quality management plan for all area. Luton Borough council I believe is actively researching an Air quality plan and have been looking into that recently but the new unitary authority will have its own transport planning function and will look internally to integrate this with its own transport people It will still have a relationship with he county council with relation to funding transport infrastructure and producing the TPP as it called - the transport policy and Programme -which is a joint venture between the new Luton county council and the new Bedfordshire County Council. I haven't heard anything about what Bedford Boroughs Plans Are - you have probably heard more about that than I have but I would be surprised if they where actually considering a air quality action plan because they do not have anything of significant in terms of topography or traffic flows through it.
4. **Nick** - yea it seems that they have a lot of traffic problems that results in ozone
5. **Charles Cousins** - Yea But I wouldn't sat that that had a lot to do with local problems, low level ozone as I understand it seem to be more related to regional, its a substance that is generated regionally from traffic flows in the South East and London and there is nothing that you can do about it locally, em you need a regional plan to tackle that
6. **Gen** - Unfortunately the environmental act does specify ozone as a pollutant, and of your over 120 ppb occasionally as Bedford is you do have to draw up a management strategy for this pollutant. Which as you said you cannot do anything about locally.
7. **Nick** - so what do you think about the regional strategy then, because when you refer to the act it does state that local authorities do need to consult with others that share a common border.
8. **Charles Cousins** well I don't think that anyone has thought about regional strategies, If you did you would have to do that through SERPLAN the South East Regional Planning Group that grouping of local authorities in the South east have begun to do some work on sustainable development indicators over the last few months.
9. **Paul Vann** - Oh longer than that over the last year -but no-one is sure in that what the county councils role would be in erm development of air quality management plans, there has not been a lot of dialogue with the districts and the Boroughs as of yet erm.
10. **Nick** why
11. **Charles Cousins** - because the districts see it has being their problem and they would go to the County when they need some information or consulting for the draft so they would so they would see the mechanism for co-operating as a sort of consultation procedure. The transport planners here have begun to look at air policy but the person mainly looking at it has gone on maternity leave so it not so much on the back burner but they are not terribly effective at the moment. It is one of the areas within the greenspace group which deal with the state of the environment reporting and assessment Realise that we have to start looking at what our role would be in looking at air quality management in the county possible through our work on travel awareness and travel behaviour such as the travelwise campaign promoting changes in travel behaviour, which includes promoting, or promotional activity needing to be backed up with changes in how the county would tackle the problem in itself that would include how we deal with car-parking, it has policies in the structure plan that aims to reduce non residential car parking, which would include schools - so there is all sorts of ways that we can approach the problem indirectly we have also been doing some discussion

in relation to design and the built environment and erm, there we will be dealing mainly with planning departments in the districts and there is a forum that is looking at design and the protection of design and aesthetics in the built environment, but we have also introduced into that design for sustainable development. and one of the key things is how you deal with parking standards and I see a lot of room there because a lot of districts are not prepared to make the first move because parking standards are important for car based commuting - which I think they are and a lot of planning policy guidance does as well, and at the moment districts are increasing perking standards to get cars off the road because they see that as being a hazard and they see that as being intrusive on the environment , you know people parking on pavements and that type of thing and that looks untidy, so they want to increase the parking standards so that in the Luton plan they want new developments to have something ridiculous like four parking spaces per household, its crazy. If your going to do that you are just going to make it easy and increase cars

12. **Gen** But if you are going to just decrease cars aren't you going to be faced with people that need to use cars, need to drive into work, and then they would be going into your area and driving around for an hour just to find parking space.
13. **Charles Cousins** but it is all about supply and demand - if you are looking at parking space then car parking can be expensive it can add to the cost of your journey so if you do not remove space but increase cost then it can add significantly to the cost of your journey and that would lead to more people using public transport and if the demand for public transport increased then the supply would increase. This is what has happened with public transport as the demand for public transport had decreases the supply has gone down so you cannot get to work easily by bus now so you go by car. But it is how to break out of that cycle. A Town like Bedford would say that we are not going to increase the cost of parking because people will just go to Milton Keynes because car parking is free, and there is a need gain for national and regional policy that is quite firm. But there are things that local authorities can do and an example of that is in Nottingham looking at parking standards as well as other means for providing transport for new development, if a new business in place and is funding for commuting by non car modes then it would not have the need for so much car parking and would save a lot of money, you know car parking space is expensive and it would save a lot of money. About £250 per space per year either rental or charges on buying. There are real economic benefits in terms of business to start changing the way that you deal with it. It is an alternative to going for this level playing field nationally and regionally which is very difficult to do because there will always be a boundary.
14. **Nick** When You look at ozone and see that it is a regional problem, in what way do you think that this parking thing could help
15. **Charles Cousins** Air pollution problems from cars are more than ozone, there are global issues in terms of cars and so I wasn't thinking in terms of local air quality plan per se, I was just thinking in terms of reducing the environmental impact of car use in an area which would generate national and international benefits by reducing CO_2 production by reduction of car use.
16. **Gen** another problem there however is that the only thing that really keeps ozone levels down in Bedford compared to a lot of the surrounding rural areas is the NO_x produced by the urban traffic since NO_x actually scavenges ozone, so if you start reducing urban NO_x by suppressing car use within Bedford, you may possibly see local ozone levels go through the roof.
17. **Charles Cousins** ah yes well that's cleaver, but its the danger of focusing on one pollutant, NO_x is also a pollutant in itself so I mean that OK there will be those interesting variations but you also have other problems like particulate pollution associated with diesels, that may be something that is mote amenable to local actions but at the moment we do not know enough about the health implications of particulate but there may be indications that these in the long term may be quite serious.
18. **Nick** - Supposing for example that the Bedford Borough was monitoring and they found that ozone was a problem pollutant. When you want to manage ozone then you have to manage other pollutants such as NO_x and VOC's and what Gen is saying is that is you try to remove car usage you may increase the problem of Bedford's ozone.
19. **Charles Cousins** - but that is not going to happen because if you are talking about VOC's then a significant source of VOC's is people filling up at petrol stations. So if there are fewer miles being travelled then there are fewer refuelling then there are fewer VOC's going in the atmosphere. So its not that simple ..
20. **Gen**- that is one of the main features of the environmental act however, they are going to make management of pollutants be based on individual pollutants in individual areas, so if your an area

that is going over guidelines and certainly alert thresholds for ozone then you are required from central government through this act to manage that ozone, Like you here are under NO_x levels so that is not a problem as far are they are concerned, but if your over ozone thresholds then you have to reduce it so if like in Bedford if your going to reduce local transport then you have this sever problem that you can go through a guideline then you manage it.

21. **Charles Cousins** - yes but that is your hypothesis that that is going to happen but I'm just saying that it may not be as simple as that. So can not say by decreasing car pollution will increase a pollutant because that would not be used as an argument not to decrease car travel because that's part of a whole wide range of other problems.
22. **Paul Vann** .. Equally I think that the technical querks of the legislation should not be something that restricts what you do. If you regard it as beneficial. If you do reduce car traffic and it does have that affect on ozone you should do it and point out that the effect on ozone and make people aware of those issues that otherwise would seem simplistic. If it means that it publicises a problem with the legislation then all well and good I think.
23. **Charles Cousins** the problem is that the science is just not good enough, because you don't know enough about the science surrounding these episodes anyway. The science cannot say by reducing NO_x your going to increase ozone. You can only test that by direct observation and experimentation, and it could be so variable that you wouldn't know what was going to happen from one year to another. So the whole issue of dealing with these sort of environmental problems is you take a much courser approach that is not just scientifically based. You take an approach that is based on say that a policy approach is taken that says an increase in car travel is a bad thing, one of the reasons is environmental, but there are a lot of other reasons why it has been decided that automotive transport systems are considered bad. They have all kinds of other external costs which are social as well as environmental, so the policy drivers are much broader than one part of one legislation, and that's where planning policies and the structure plan are quite robust in that sense in that they are social, environmental and economic driven so you actually have a bit more of integration there so it is quite helpful.
24. **Nick** - so you see this piece of legislation as too simple because it is not integrating other factors
25. **Charles Cousins** - Er no, I'm not saying that it is a bad piece of legislation because local air quality management plans will help us do some things and they will certainly make us look at new ways of integrating air management by drawing in transport planning, land-use planning and environmental health monitoring functions, and it will give a focus for some of your local campaigns for changing transport behaviour perhaps, but it cannot sit on its own it has to have a relationship with all the other policy instruments, which are dealing with the same problem. So it itself needs to be integrated.
26. Nick - the erm, underneath the county council functions - information exchange as reasonably requested - how do you classify information exchange, is there any information flow between borough and county - are there any limits or restrictions or ...
27. **Charles Cousins** - I would say none, there is a total and free exchange of information, and when I say free I mean no cost so generally we don't charge.
28. **Nick - so there isn't any difficulty in this**
29. **Charles Cousins** - No Id say none at all
30. **Nick - So they county council should submit the proposal and statement, especially outlining the time-scale, what do you think about this proposition.**
31. **Charles Cousins** - yes we have already got some things in the transport plan that address air quality but they are pretty crude because of the way we are trying to assess our transport plans and policies,
32. **Paul Vann** - are you referring to the TTP there or not the county council strategy,
33. **Charles Cousins**- Yeah, the strategy says a lot about air quality as well but we need to have a better approach to the way our transport planning functions, .. in which way which bits actually have an influence on travel behaviour, traffic flows and therefore air quality, it such a tenuous link but its several steps down the line from investing in transport infrastructure which is what TTP is all about in the main. Its about capital investment, there is some money that we manage to get which is like for non capital, like travelwise work, and some of the work on promoting bus transport. That is an important thing to remember is that we don't just have a TTP that bids for money but we also are still passenger transport authority and so have the ability to subsidise routes and users so we do spend quite a lot of money a year on bus passes for pensioners, bus passes for children to get to school and subsidising certain routes in the county and that is often overlooked

that that policy mechanism that has been in place for a long time can actually be used in different ways to reduce the use of the private car.

34. **Gen - Going back to this problem of local authorities having to manage within their own areas, even county councils that have influence within the county borders, where you could be faced with somewhere like London that decides its not going to manage its own area which is a possibility by the way if London is allowed to manage its air quality only in the winter which is the time of year where pollutants are a problem, is there a big argument for some sort of infrastructure that allows one county to influence the policies of the other council, I know there is SERPLAN but are there other groups that can work as a mediator.**
35. **Charles Cousins** - well there is SERPLAN which the main way over which authorities co-operate, but there are other ..
36. **Paul Vann**- There is also the county forum that's just starting - it a chief executives association it just starting . I think that will complement SERPLAN in other aspects of local authority interest.
37. **Charles Cousins** - don't dismiss SERPLAN as a mechanism for dealing with environmental issues., it deals with waste and minerals at a regional level and it manages to actually ... it produces guidance that has real effect .. and also housing .. that's where the housing figures come from.
38. **Paul Vann** .. I looking at vague recollections of things .. but em but a main body in relation to air quality is that there is a sort of network,
39. **Gen**- it the warren spring network I think
40. **Paul Vann** - Is that a small level extent
41. **Gen** Eh no but I believe that the borough councils are organising a network but there is some disagreement as to who does what and funding and so on
42. **Nick** Do you think that co-ordination between county and districts necessitates a new structure or do you think it can be done without any new structure.
43. **Charles Cousins** - I think my expectation, I don't know whether it is hope or expectation, but we are over the worse in terms of our relationship with district councils - its improved with Luton Borough I even pre- re-organisation, and even though Luton is going its own way it has improved and communication has probably grown since we knew that result and its fairly strong with mid-beds and south-beds and I think its even getting better with Beds Borough. So I am reasonably optimistic. Its certainly the attitude of senior management here is very much one of co-operation and I think that's..
44. Paul Vann - I don't think you need a new structure, I think you just need a recognition of the importance of good communication and co-operation, Because you have got professional problems of integration and you have got the fact that environmental health and panning do not work together very often. Environmental health and transport planning have probably never met and you have different attitudes in the way that things are approached, going back to SERPLAN that is predominately planning orientated and what we are talking about here is something that is predominately environmental health dominated and environmental health has not established a regional structure for the service it has delivered historically, the thing that has acquired that regional structure is planning and it is well developed and it works, so what you do with integrating environmental health and planning in this area, and you have of course got planners at two levels as well, and I would deal with transport planners as different as well, they are different professionally, so you have to consider all those professional relationships and I don't think you need a new structure for that I just think you need a focus, and you do have a focus of air quality management and it could actually bring some benefit somewhere

45. **Charles Cousins** - I think that that is right actually Its like a stick that helps bring people together.
46. **Gen - so rather than a practical tool its just a nice way of saying look you lot it time to start getting together and looking at this ...**
47. **Charles Cousins** yes ill accept that as being the practical outcome
48. **Gen - so basically to wrap up one final point is that we have talked a lot about county councils talking to other county councils and district councils talking to county and together. What influence do you have as a county council on central government policy that affects you.**
49. **Paul Vann** gosh yes that is a very difficult question to answer, I would say that there is no physical direct influence but the influence is continuous ....
50. **Gen - Significant**
51. **Paul Vann** - (pause) erm I would say significant - If you look at things like PPG6 then that came from local authorities, the pressure for that .. and that's quite a major policy approach

52. **Gen - And I believe that the relaxation of the hard cost/benefit analysis approach was also a result of the same**
53. **Charles Cousins** -yes There is a phrase called the complexity of ambiguous confusion that sums up the relationship between central and local government and I think that is the reason why it is difficult to say whether there has been significant influence in these policy areas. Because so many of these policy areas are ambiguous and they are confusing
54. **Nick - Do you think a structure between the two is better to co-ordinate different councils like a regional government**
55. **Charles Cousins** but I think that ambiguity is deliberate at a political level and what happens if you start talking to someone about what is happening it can easily confuse them over what is going on and any criticism can just get absorbed into a sort of mush and they start punching at a sponge.
56. **Gen- a sort of political no mans land**
57. **Charles Cousins** yes there is all that manoeuvring going on and there may also be short term advantage for local government and also central government. They can exploit things, its a big game.
58. **Charles Cousins** - one thing I should mention is that we are hoping at the next LA 21 forum in October to look at air quality management and to get reports from the districts,
59. **Gen - do the county have a lot to do with Local agenda 21 or is it really up to the districts**
60. **Charles Cousins** - em we initiated a county forum in 94 and that meets two or three times a year and we do contribute to the work at the local level, but it must be said that things are very slow in terms of district and local agenda 21. They're doing a lot of work but it is taking a lot of time to get anything out of that.

Bedford County Council *03/07/96*

Interview 11.30-12.15
Present: N. Cottis
Howard Newby, Senior transport planner, Bedford County Council

N.Cottis presents his documents to ***H.Newby*** and asks him to comment on co-operation between district and county council

1. *H.Newby*:
2. It is very early yet in talking to district councils.To a great extent, air quality data monitoring is not taking place at the moment, so it would seem.. is it a lack of co-operation ?, or is it a lack of sitting down and seeing how this thing is going to work.
3. I thought that things haven't been sorted out yet, that monitoring haven't been set up yet.
4. Certainly we make traffic data freely available , but at the moment there isn't the air quality data to compare it with.
5. If you take South Beds with Dunstable town centre; They rent some equipment, diffusion tube equipment, in Summer 95, to look at the air quality, at the pollution.
6. We compared this data with traffic flow data, and we found no correlation at all.
7. I think they are the only people to have done this work so far.
8. It is the beginning but it is very early days yet.
9. The fact that we didn't find a correlation doesn't mean that there isn't one.
10. It has possibly to do with other factors such as the time of the year
11. ***N.Cottis*** asks him if any model exists for integrating those factors
12. *H.Newby*: In our planning group, we don't have the knowledge to integrate other parameters
13. We need to talk to the district
14. ***N.Cottis*** asks him if they're developing a model of diffusion of pollutants
15. *H.Newby*: That would be the ideal to have the model, but we didn't go very far in that road to doing that yet
16. ***N.Cottis***: If correlation was found, and if the problem in Bedford was ozone, what remedial action would you suggest?
17. *H.Newby*: My understanding was that that ozone monitored in Bedford is a result of traffic flows elsewhere, putting hence the action on co-ordinating work across the whole country certainly.

18. I think at the moment ,our view as a group that in hot spots the problems are not so severe to make road closures.
19. Even if you carry on doing that, it is likely that emissions will go up generally in the area, because people will divert around the closure
20. So the way we think our transport policy will develop in relation to air quality is in a general way, in terms of general traffic restraint
21. Because we would guess, that it is a general level of poor air quality that is the most significant problem, and the future problem.
22. We've got to be part of a much wider attack on air pollution
23. But at the moment, it doesn't look like the hotspot problem is the more important one
24. That also seems to be the Government's view
25. At this stage of the game, it may be due to the fact that in Bedfordshire we don't have problems like , for example in Cambridge with the Canyon effect.
26. *N.Cottis* then talks of the polluter pays principle, imposing tolls on motorways.
27. *H.Newby:* What about taxing the fuel. I suggest that, rather than taxing the ownership of the vehicle.
28. It has been suggested many times, that we should get rid of the road fund licence which is £120 per car per year thus applying the polluter pays principle and stick all that on the fuel.
29. *N.Cottis*: action has then to come from the national government.
30. *H.Newby*: The Government has got this proposal to increase the price of fuel by 5% every inflation every year.
31. I think the Commissioner on Environmental Pollution suggested that they should much further
32. Because for example the problem with that in an area like Bedford, is that the extra cost on the fuel is going to be insignificant in the people's decision to use the car
33. Which is why the other proposal that we're making i.e. to reduce the amount of car parking has more going for,as a measure.
34. We are proposing that the amount of all-day car parking in the centre of Bedford and Luton be reduced, charges made for it be increased,
35. But at the same time adequate short-term car parking in the centre is maintained to protect the vitality of the town centre,
36. So at the same time we're promoting park and ride and we're promoting public transport and encourage people to change modes.
37. We're also beginning to promote cycling and walking.
38. I think other Local Authorities' agenda is to do with these measures.
39. We're sceptical in closing roads
40. It might have a role in reducing traffic in the town centre, but as a measure to reduce pollutants, generally, closing roads has big disadvantages.
41. I think that the Government is looking for general traffic restraint which to be fair, the fuel duty will encourage, rather them attacking hot spots.
42. *N.Cottis*: What about the balance between your proposed measures and economic interests?
43. *H.Newby*:We are planning to maintain adequate short term car parking for shopping.It is really the old day parking for people seeking employment in the town centre that we're targeting.
44. *N.Cottis* asks for comments on public participation.
45. *H.Newby*: We are promoting a campaign in this county, Travel Wise, to encourage people to think about car problems and alternative means(travel to school, encourage people to other modal split.)
46. *N.Cottis* asks for comments on increasing public transport
47. *H.Newby* :Deregulated public transport system is not helping the county(Transport Act 1986 implemented by 1995).Bus services are private and it is difficult to askprivate operators to change routes. Moreover the EC Green Paper is not helping public transport.
48. Other problems: offstreet car parking is controlled by the district authority while on streetparking and highways are controlled by the county council
49. This therefore necessitates the agreement of both to successfully implement policies.
50. *N.Cottis* asks for final comments on the EA 95.
51. *H.Newby*: I think that the EA 95 have some limitations, because it imposes duties primarily on district authorities; But because we are dealing with traffic problems then these duties must be primarily within the responsability of the county council.

52. Moreover, some of the air pollution problems are regional, and district authorities have no ability to tackle the problem.I suggest that SERPLAN should have guidelines for district authorities in our area to integrate the EA95.

BEDFORD BOROUGH COUNCIL 11/07/96

Present:
Barry Williams, Environmental Health officer
Jane Hill,Senior pollution control officer
N.Cottis
G.Cannibal

1. **B.W**: The way we're organised in the Borough Council is basically on specialist lines.On pollution, pollution covers all env. media, and we have a small team doing that.
2. the majority of our work is responding to problems from the public, about 75%. We're very responsive to customer's needs.
3. we have a routine programme such as authorisation of processes prescribed under part B processes of the EA 90
4. the general principle is that Env.health departments deal with the less complicated processes
5. air quality we've been involved traditionally for many years but the the EA90 and EA 95 have given us new duties which we anticipate will be coming onstream next year
6. **N.C** presents his documents and asks for comments
7. **B.W**: I'll leave you with Jane to give you an overview of air pollution proposals for the future, but we see essentially assessment as the first stage
8. we are working on a regional basis on this, because air pollution is not an issue for one district council; we perform together, we've established pollution groupings in Bedfordshire and Hertfordshire.
9. **N.C** talks asks for comment on information exchange with County Council
10. **B.W**: there is no mechanism set up yet, although we have had one provisional meeting with the County Council.We have commenced the dialogue informally.
11. **J.H**: Beds are acting on its own.Once the requirements of the act became apparent, we contracted a consultant to prepare a brief for us, so that we would know what we had to do when the implementation date become forward, so we can go out for a consultant at that stage to tender for the service which would be a compilation of our assessment, through recommendations..That's been suspended because of the delay in the enactment of the responsibilities and possibilities the local Beds and Herts are looking again on what can be done on a regional basis because it is a regional problem.
12. within Herts and Beds we have major motorways, we are upwind of London, so there is a lot of air movement so this is why we act as one region.
13. **G.C**: but this is respected to the Herts and Beds
14. **J.H**:at the moment it is still not developed more.I've been working as part of a small group acting under the Chief Env. Health officer group in the Herts and Beds region and we've been putting some recommendations about where we need to go in the region.
15. the stage we are at the moment is that we've identified the way we feel we need to go forward.
16. the first stage of that is have we got enough data? well we havn't.So were do we want to go for the data.
17. the information from the DoE is that we must be using as much use of existing databases as possible rather than setting monitoring sites everywhere
18. it will be a tiered approach starting with the crude overview assessment looking at the main transport routes and EPA processes.
19. What we've identified is stages that we feel we need, the inventory stage to gather all the infor.
20. part of that will be links with the County Council
21. because they've got a lot of information we need.

22.one of the recommendations is that we form a local grouping incorporating the county councils and invite them to participate

23.altough we are the regulating body,we can't do it without the information and cooperation of the county councils

24.from my point of view I think it is best for us to take yhe initiative

25.**G.C**:it is an interesting aspect to see that the district councils have the main role in air quality.

26.**B.W**: there have been some changes recently, on transport planning.I believe many of the agencies functions that district and county councils have given each other are now being taken back. The dep. of transport will be looking in the future on major strategic transport routes to put those on design, build and finance arrangements with consultancies. How that impacts on transportation strategies locally remains to be seen. Take for example the A428, there is no doubt that there will be local consortium arrangements with entrepeneurs and interest parties.We need western links to the by-pass, there could be a caracteristic approach which is not necessarily good to the env. The other issue is that the Gov., on allowing these roads to be put out to these design and build consultancies, the revenues are based on traffic flow data, so therefore there is an incentive to increase traffic, which is counterproductive on env.matters.so in air quality,env.strategy and transportation policies are dimensionally opposed in terms of UK strategy, and that worries me.I certainly agree with you that there should be an improved dialogue, to integrate these policies,but why should the Gov., why don't they take it to the national level.they surely can't expect..this is precisely the problems that would arise, the engineers, and the DHO's won't necessarily be talking at every district council level.

27.J.H: Even if they are talking. at the district council, at the env.health department we go out and do our review and we come back with results that say we need to take remedial action, then what's the likelihood ao th department of health talking to the highways and transportation people and getting that thing coordinated?

28.B.W: that's where the Gov.guidance will be giving us guidance. One of these will be how to develop a transportation management plan.The key features will be an interdisciplinary approach, becuse we're not the only key player in this and the engineer will have the lead role, but it remains to be seen which department takes the initiative, which will be interesting.

29.G.C: Do you see, the movre to approaching air quality in a sort of plan based system, could do what structure planning did to land use and transportation planning, in the sense that it brings env.health and transport planning closer together within local authorities by requiring them to work together?

30.**B.W and J.H**: Yes, we definitely agree with that

31.**B.W**: We feel isolated sometimes.

32.**J.H**:We're long way from that, light years away.

33.**B.W**:I think that there are always, have been interest and env. issues don't take the highest priorities, when significant decisions are being made on many infrastructure matters, because env. matters can be prejudicial to development, in terms of housing and roads, but I think that the profile is rising and we're keen to be party in the future.In my experience from the past we have been out of the limb, but we're working now towards a more structured approach, but we need the Gov. advice on how this thing can be coordinated.

34.J.H: In terms of practicality, the DoE are not expecting so many air quality management areas.

35.G.C: So we're talking of 4 or 5 air quality management areas

36.B.W: My personal view is that the Gov. approach on Env. matters is not particularly good.

37.We don't tend to take a pracautionary approach as Europe does.We're been given to chip away in this now and air quality management plan is part of the chipping away process.
38.In due course what will happen is that we may have 4 or 5 air quality management areas in the U.K say in 2,3 years time but as standards change and awareness increases and epidemiology improves, then no doubt more local plans will emerge to deal with these issues, so yes, 5 may not seem so much so what's the point if there will only be 5, what's the point of going through that process?
39.What it is doing is that it is developping a methodology to enable us to move ahead in the future
40.N.C: So it is not a critique that you're doing
41.**B.W**: Let's be positive.First of all to what it is going to achieve. I really feel that national strategies will achieve more than local stategies initiatives.
42.To be honest, the Gov. ought to look for alternative technologies for transportation, they ought to be looking for subsidisinf the railway system, looking at other means of fuel for transportation. The Gov. could, but it is politically sensitive for the moment, and they do not want to take the risk of causing any major problem.That's the answerLocal traffic management is tinckering the problem.
43.Rediverting traffic and harvesting the road is only going to have a minor effect on air pollution.The major effects will be on new fuels, cleaner fuels, new technology, looking at sustainable development of communities locally, looking on how people move about in the country.
44.**N.C**: Why don't you create a lobbying group?You are all aware of the problem.Why don't you sit together and come up with a common proposal.You know from where the solution must come from.
45.**J.H**: We would have to report to commitee structure and commitee would need to endorse to lobby ***a*** ***,b,*** ***c.***
46.**B.W**: We have a very tight bureaucratic structure..political accountability.Ther is no doubt that the commitee is aware through many reports of the main issues, but I can't comment on that issue.
47.**N.C**:We have an ozone problem, but we can't do anything locally!
48.**J.H**: Yes
49.**B.W**: I think that's accepted by the gov.It hasn't introduced an ozone air quality action level.
50.**G.C**: Europe is insisting on an ozone, NOx, CO2, CO standards.If Europe says that there is an air standard then the Gov. will really would have to go for it.
51.**B.W**: The Met. office predicted that ozone will take a number of decades before it approaches the 50ppb limit. By this time no doubt it would have been reduced even further.
52.Ther is no solution locally for ozone. Reducing NOx and VOC's will have an adverse effect on ozone as we know because of the sink it is providing for the moment.
53.The solution is a transboundary pollution control.
54.That's the only way Bedford can reduce ozone, this is well recognised.
55.**N.C**: For another pollutant, interdepartmental cooperation can reduce its concentration, but we're talking in Bedford of ozone. It is the only pollutant exceeding the limit
56.**B.W**: Well NOx is very close;we are monitoring NOx by using diffusion tubes at the moment and we have had levels that have approached the limit values but we can't say for certain if we've exceeded because diffusion tubes methodology is low tech, so NOx may be an issue.
57.**J.H**: I'm sure there are likely to be times where NOx has exceede the short term limits, before we got to a stage of going through an assessment and a review.
58.I would like to supplement that with a little bit detailed monitoring to substantiate.We're looking at the avenue we're going down the road,we're going to take tis data and we're

going to model, but then we need to substantiate those results to confirm whether or not it exceeded.

59.**N.C**: We've got a wide range of pollutants..what do you think is the priority in the act?..is it to tie pollution to public health? how to assess air quality against specific levels of certain pollutants? What do you think the aim of the act is within that contexy??

60.**J.H**: The act doesn't recognize exposure

61.all we have to do is to go out and measure and if you exceed that's it. That's the area that has been omitted

62.**B.W**:We have prior legislation, what we need now is a circulus.We don't know the spatial resolution of the assesment

63.I agree with you the objectives should be not only tolook at the impacts but at the effects of those impacts.

64.There is a need to link these to epidemiology and health statistics.I believe the Gov. have recently proposed a major study of major cities.What is tha distribution of health related diseases?in hot spots?I'm sure many GP's would say that there is a correlation, but prove it.

65.We would be interested to follow the trend of respiratory problems associated with the growth in diesel vehicles. A correlation there would be an interesting proposal.

66.**J.H**:Diagnosis have also changed the last 10 years.What is considered now as a respiratory problem, was considered as bronchial infection before.

67.**B.W**:It may well be that we are only considering asthma and this health related data.What we ought to be ding is looking at people that are sensitised to traffic pollution, that may not necessarily exhibit clinical symptoms, but are affected by that, but not necessarily go to see a doctor

68.So the size of the problem could be larger than what we are aware.

69.**G.C**: What does air pollution mean to people?If you want actually to cut down air pollution , it's in their behaviour.People have to care in order to change their behaviour.Public legislation crossover seem to be neglected by the act..

70.**B.W**: One needs to look at human behaviour in any sort of strategy to deal with that particular point

71.It takes several years to take the message for health related pollutants, particularly for carcinogens.By the time we get the message it's too late but that's the function of the human behaviour.We do not learn by our mistakes

72.For example free lead petrol, we all knew the problems associated with lead but it wasn't until the pricing policy changed that the public took lead free petrol.So we knew the health problems, but only when the prices rose, that they've starting to use lead free petrol

73.**N.C**: Are there any campaigns to aware the public?

74.**J.H**: Very low I have to say

75.It is not a lack of wanting to but a lack of resource and time.

76.we do report and advice the committee and they're aware of our routine programs because they see that annually.

77.we recognise the need to talk to the public, but it is very time consuming

78.some auth. produce detailed reports of all their monitoring throughout the year.We can't do that, simply because of time.

79.**G.C**:Under the air act..release resources of departments for public communication..

80.**J.H**: I would like to think so.It would involve our engineers and env. health people

81.each authority will implement the EA in a different way

82.the DoE has clearly stated that there won't be funding for anything which is not statutory

83.**N.C**: What about putting resources of planning, env. health and landuse together?

84.**G.C**:this is why you need more flexibility..

85.**J.H**: we haven't got the detailed guidance, so we don't know

86.regulations will be very specific.It will be laid down quite explicitly

87.B.W:The Gov. may well be taking time to develop all this;guidance will be needed quite soon because we're moving towards the money, the budget round.That's very soon, for next year, so therefore , I think it will be highly unlikely that we will be doing this process, across the country next year.With the emergence of the environment agency, they will be looking very critically on how they perceive their role in terms of national strategists.No doubt they will be the key players in this, although the response is at local gov. level

88.the agency, if I was at the agency,I would see them taking a much wider co-ordinating role, across regions probably, and pull together local authorities from these regions and co-ordinating on a much wider basis.But this remains to be seen.

89.N.C:What keeps you from going to the County Council and asking them for traffic flow data and collecting and comparing this data with monitoring data?

90.J.H:Nothing.We've already started the process last year, but it hadn't been pulled on a regional basis.

91.G.C:Everybody around Bedfordshire has heard about the housing issue, about the conflict between county and district.If you do an air quality management plan, in the area you're talking about,transport, do you think the county and district will work quite closely on a regional transport planning, or do you see that as conflict?

92.J.H:I don't know.You've got different levels here.You've got officers working in relationships and then you've got the high level policies and politics.

93.G.C:The actual politics, elected members, do they have influence on how you would implement the EA 95, on how to contain traffic behaviour?..

94.B.W:Very much so, because it would have resource implications.The politicians have a major stand on how things are organised in local governments.

95.G.C:Air quality management has always been identified as something the env. health, transport planners, landuse planners have a major role in.Do you see the env. health as having that central role in the future or do you see the need for other departments such as social services, education..?

96.I think our role is to primarily collect information, and to monitor the environment.I think decisions will be made upon the data we collect

97.we will be part of that decision making process.But given that transportation policies and land use policies are going to bring more information to improving the environment.I think that the lead role,will be in those areas, not necessarily in ours Traditionally, our role is to collect data.

98.implementing major policies has never been our main role.I don't see that will change

99.our strengths are in monitoring, in solving problems

100.G.C: So your key role is an information role rather than an intervention role

101.B.W: With some exceptions.We have some regulatory functions on some processes, but on a very local, process level.

102.J.H:I think any role that we would have will be an advisory role, to those who are making those policy decisions.It would be good to think that we had the capacity to be more forceful, if we felt we needed to be on certain issues.At the moment, we are looking towards regulating with the planning department on applications that come in on a local significance, and we give them advice, and if necessary, we will object to certain applications.

103.It will be good to imagine that we could be in a scenario where that was developed.

104.G.C: So do you see the need to communicating, air pollution data, the identification of hot spots, to social services, education, those that deal closely with people?

105.B.W:People who are susceptible individuals in the env. no doubt strategies will develop for them to be aware of measures they can take to minimise their exposure.For example, asthmatics, when we anticipate that conditions will be such that ozone will be high in Bedford, we can't do anything about it.

106.At least we know who the target audience is out there so we may be well to advice them.So the same principle could apply to other individuals and certainly that will be a potential in the future.

107.**G.C:** One of the big problems of ozone is that there is emerging evidence that there is long term lung damage as a result of exposure to ozone in childhood.So could you ever see the issue of air pollution information on education departments saying don't let the kids out on a day like this between those hours?

108.**B.W**: Well isn't it a shame that it will have to come to that!Surely, the Gov. has to look more strategically at those issues, instead of having us to respond and setting policies and procedures to cope with situations like that!

109.**G.C**:..Population will start to put more pressure on the gov.

110.**J.H**: Possibly.That's where changes have come from. The reactions aren't so effective in terms of policies that are implemented, but once you start mobilising the general public..

111.**B.W**: We will have some significant battles in the future;there is a correlation between roads and economic developments, but there is also a correlation between roads and environmental matters, and the two will always conflict;economic developments have high priorities

112.**N.C**:In order to prepare a complete assessment of air quality in the area, do you need additional monitoring?

113.**J.H**:Undoubtedly, we will need to have additional monitoring.The information we've got is based on diffusion tubes and pilot surveys.If we're going down the road to the DoE in terms of advocating, using databases as emissions characteristics, we could get a broad brush inventory for our area.At that stage we have to start and model and estimate what the concentrations are, then we will need to look at additional monitoring.

114.There are some problems, we've not even looked at in Bedford..benzene, we've done little..

115.**N.C** asks **J.H** for a quick yes/no on the following:

116.collate historical monitoring:yes

117.compare to standards:we will be doing that

118.identify areas of greatest pollution:we've got an idea where the problem will lie

119.emission inventory database:no

120.low tech monitoring at points of concern:yes

121.**J.H**:The EA 95 is really too simplistic

122.**G.C**: the good points of the EA 95 is that it will raise the issue-**J.H**:which is the best thing about it- and it will get env.health, planning and transport working together in local authorities

Bedford Borough Council *08/07/96*

10.00 - 11.00

Present Nick Cotis/Gen Cannibal Cranfield university

David Logan - Borough Engineer, Bedford Borough Council

Richard Woodall, Planning Policy manager, Bedford Borough council

0 **D.Logan** - (Outlines the 1995 EA part 4 as he sees it.)
1 Act to be in place by July 1997
2 Job plan falls to the Director of Environmental Health and Housing, Nevil Hobday - director under Barry Williams - first sight = essentially collection of monitoring data.
3 Richard Woodall & David Logan involved in land-use planning & highways development respectively.
4 Context of their remit is set within a range of policies, set by central government
5 PPG 12 & 13 - sustainable development states for example
6 Most problems in the Bedford Area are from Traffic
7 there is a need to integrate Traffic Policy ?highways planning and land-use planning
8 settlement should be situated around transport corridors - however that leads to worsening air quality for residents along those corridors as traffic increases.- also there has been a steady removal of highway planning from the public sector.
9 No consideration of life-cycle testing within the context of private car use. Under costing of the private automobile. Notes the advantages of the flexibility of car use.
10 Privatisation of public transport
11 central government is inconsistent - leads to a main issue of cynicism of central government at district level .
12 Monitoring ids perhaps the easiest of the problems surrounding the act: technical problems of how are easy, but problems of why and where ? there is a major problem of identifying monitoring strategies for informing policy option.
13 Position statement is Why and where are we monitoring and does it inform policy making. We are in this position.
14 The range and depth of data is not a simple issue, especially when you consider the transport of air quality.
15 We can theoretically do something !
16 But exported pollution is a difficult problem
17 SERPLAN is a joke - it is appointed by government - to a degree to keep the lid on problems, not to deal with them.
18 Yet the question arises - Why should London be able to export pollution ? where is the polluter pays principle ?
19 Central Government is good at passing the buck - but not dealing with the causal problems
20 This leads to a certain cynicism on behalf of local authorities - they see that the policy will not work and therefore do the minimum to appease central government.
21 **Gen - does this lead to problems of dedicating funding**
22 **David Logan** - The problem of financing is more subtle since local government plans last for ten years - and infra-structure is a long term project, policy cannot be changed on the hoof - there are many solutions but those legalisation imposed by central government do not work, I think if councillors believed that they would work then they would put up the money - so there is a shortage of finance but it is cynicism over central government policy that leads to unwillingness to spend.
23 This is an important issue - it raises and addresses another very important issue there is a push to integrate transport/land-use and the environment - but this is not consistent with other policies for example privatisation over which I have no personal ideological views -but it does need regulation;

24 For example bus deregulation - promotes the use of commercial routes at the cost of closing non-commercial, the efficiency of public transport is now measured in terms of purely financial efficiency. - while private investment can be dynamic - government must regulate output.

25 **Gen does this rise of private ownership of transport modes hinder the local authority in providing alternative to the private car - in so far as for example comfortable bus services are concerned.**

26 **Richard Woodall** Local government now only produces plans - we are enablers - we do anything about it.

27 **David Logan** In Europe there is more representation of local government -here there is poor connection between national and local government due to the lack of regional government - there is no communication there are associations of local authorities with some voice ....

28 **Richard Woodall** ... but in the last ten years there has been open hostility by central government to local government, these association give representation to central government, but central government tend to go through the motions rather than pay attention.

29 **David Logan** Central government more pushes its view on local due to the funding arrangements (local government gets about 70% of its funding from central government) and its non-consultation style. Presently the approach is to exercise financial and policy control over local government.

30 **Richard Woodall** - Just look at the amount of actual development decided at central government level

31 All the district councils objected to the county plan, this was produce through central government guidance, in the regional housing plan - county said the housing allocation was too high but were forced to comply.

32 All districts objected to the county plan but where forced to comply by central government, new residential development are all road based and set

33 there was no local control over this development.

34 Basically all plans where set and dictated by central and local government

35 **David Logan** and Bedfordshire is not special. What is special in Bedfordshire is we have a set of problems like landfill and two major motorways in a small urban county and a poor attempt at local government re-organisation.

36 Luton going on its own is going to have great problems - historically there has been a regulatory - value approach to green-field development -redevelopment has been greatly ignored since it was too costly and difficult Luton really needs a development area to plan effectively - within Luton itself- and without this which now rests in another authority it will be in trouble.

37 Re-organisation was essentially politically led rather than for greater efficiency - Luton do not historically get on with neighbouring districts, most of these small districts do not want to be a part of a bigger Luton

38 Needs to retain the historic shire of south Bedfordshire & therefore the residual county, isolate centre/left Luton and possibly return Tory seats (possibly although that is not guaranteed at the moment)

39 **Gen - so problems are essentially of poor communication with central government**

40 **David Logan** - a large part of the problem is central government - but integration within an area i.e. getting colleague to work within a local authority, across disciplinary and cultural divides can be difficult

41 **Gen - are there specific round table meetings for this purpose**

42 **David Logan** Yes and this works better in some areas than others - our divisional heads meet and exchange views and personalities do tend to get on well and a good synergy arises - it works well, were it doesn't work well is when one department works outside this ring - this can be partly due to organisational reasons or partly personality but we do have meetings of departments and

43 **Richard Woodall** for the 1995 act it would be that environmental health would set up a working party. I thought that environmental health would be here today and am quite disconcerted that they are absent.

44 **David Logan** - meaningful outputs tend to produce co-operation. However insular behaviour alienates other groups. In Bedford we tend to have all the main departmental groups consolidated into one group and this can work well-co-operate working can lead to communication - but it is personality dependent.

45 **Nick Cotis introduces his list of requirements (see accompanying document) of the 1995 EA Act and asks for comments on these**

46 **David Logan** - The thing with Air Quality Management Areas is summed up in the old adage - never set yourself up so that you can fail: a local authority would be very careful of the area selected - what are you seeking to do, what can you achieve - how would you designate area

47 **Richard Woodall** there are things that you can do when monitoring areas, for instance it is known that air quality tends to be better in school holidays due to less cars. But an action plan even integrating transport and planning there is very little you can do.

48 **David Logan** Traffic management only slows vehicles :

49 However there is the big one - reduce private car use - this would require management of modal split - there is no hope of this within the context of central government policies - although there is regulatory control - Counties now have new powers to restrict peak area traffic for instance in a case where there is high pollution levels - but this will result in them screwing up their town's economies - people would just go to Milton Keynes ....

50 .... Or we can play games and traffic management just moves pollution around

51 **Nick Cotis - within twelve months draw up an action plan**

52 **Richard Woodall** Rather than dealing with the root causes of the issue they (central government) are just dealing with a few hot spot problems they need to approach the problem of car - the polluter should pay

53 **Nick Cotis - recommendations for consultation when setting up quality objectives**

54 **David Logan** - local authorities must consult local authorities, the relevant regional authority & central government? Here again to what avail if there is no funding the plan could be wonderful but with no funding what could be the useful output

55 **Nick Cotis - what about the EPA**

56 **David Logan** the EPA - well ditto - its a Quango no funding and no regulation.

57 But other local authorities is interesting -

58 **Gen - will local and district authorities talk together**

59 **David Logan** very badly - the county is abysmal as for working with other authorities or LA's within other authorities well there is the association of district and county councils

60 But the highway authority is only an agency of the county council - and in Bedford only roads within the urban area are under our control. Between the Borough and County Councils there is cultural separation they are very distinct from each other.

61 When I was referring to the desegregation within a council, this is more so between. If there are recommendation for policy change - then there's the question of funding who is going to do it district or county.

62 **Nick Cotis - draw up a management plan**

63 **Richard Woodall** On top of this there is the problem that the people who identify problems are to manage them leading to the physician heal thyself situation.

64 The bottom line will be who is going to find the resource and how is it to be delivered.

65 **David Logan** there is a basic management rule that can be found in all the books and so on that is "never give responsibility without the authority that goes with it

66 **Nick Cotis and what about setting up time-tables**

67 **David Logan** outlining a time-scale will only get local authorities into a box -there's no incentive - back to the physician problem. The situation should be judged by its outputs not inputs.

68 **Gen Cannibal - would you say therefor if for instance you where a chair of a local authority needing to identify AQMA's that there would be any incentive under this act to do so**

69 **David Logan** - no, no willingness at all, due to the extra constraints it would place on the authority finding the extra funding and having to impose extra legislation -

70 **Gen Cannibal so it basically comes down to problems of co-ordination and communication**

71 **David Logan** - yes and to wrap up on that subject I'd just like to mention Local Agenda 21 which is also in the remit of local authorities devised by central government -

72 Bedford Borough is approaching this big politically - going for the bottom-up process

73 allows working groups - running and decision making up to the community.

74 Many of the problems are up to the community to solve and some things need local government input.

75 Government has set deadlines for Local Agenda 21 reports - but what will it do with them I think they will go straight onto the shelf

76 However Local Agenda 21 has closed the gap between people and the local authority - we need to convince the public that we are acting on their best behalf - communication and involvement.

77 Local agenda has bought the government time: and let the local authorities deal with it analogy to the EA 1995 -

78 But the town hall has tried not to talk down but listen

79 **Gen Cannibal - but since the local authorities have very little ability to affect change doesn't this just lead to public expectations being blocked at a higher level**

80 **David Logan** - but we can demonstrate Local Authority Cynicism to a larger audience and show the constraints placed on us by central government. And air quality is just one threat that we must resource the solution to deal with the problems.

Appendix 3: Data Sets used In Chapter 6

The UK emissions inventory

The following section is adapted from: DoE, 1997 http://www.aeat.co.uk/ netcen/ airqual/emissions/*.html

The National Atmospheric Emission Inventory (NAEI) is funded by the UK Department of the Environment to estimate and monitor emissions of a wide range of air pollutants.

The NAEI estimates national total emissions of a wide range of pollutants for each year since 1970. It also produces spatial emission maps of selected pollutants. This data will also contain some projections of future emissions of some pollutants.

These figures are all estimates of emissions as it is clearly impossible to actually measure the emissions from each car, home and factory in the UK (see "UK Emissions of Air Pollutants 1970-1991" by Gillham et. al.) AEA Technology's National Environmental Technology Centre.

The maps are compiled on a 10 x 10km Ordinance Survey grid covering the United Kingdom. Emissions mapping gives a guide to the spatial distribution of pollutant emissions across the UK. The maps form a useful basis for deposition and pollution modelling and as an aid to locating new monitoring sites. Comparisons with measured concentrations will help to validate the mapping and emission estimation methodologies. The existing methodology used to map emissions data categorises the sources into one of two groups,

- Area or Point Sources.
- An Point source emissions

Area sources, such as domestic combustion, agricultural activity, road transport, shipping etc., are those sources too numerous and disperse to identify individually. Area sources are mapped using data relating as closely as possible to each emitting activity.

A proportion of the National totals for each area source is allocated to a grid square according to the proportional distribution of key source related categories. For example, the UK total aircraft emissions are mapped according to the proportion of takeoffs and landings for each grid-square. Obviously in the case of aircraft most of the grid-squares will have a proportion of zero and only those covering the major UK airports will contain a value (http://www.aeat.co.uk/netcen/airqual/emissions/*.html).

shows some of the key emission, groups, and data used to map the area emission totals.

Table 1: Sectors and Data used in estimates of regional pollutants (afterhttp://www.aeat.co.uk/netcen/airqual/emissions/den-naei.html & mapping.html

Emission Group	Distribution used for Spatial Mapping
Air	Air Traffic Statistics Take Offs and Landings for Major Airports
Railways	Rail Transport Statistics
Coastal	UK Fishing Vessels Distribution
Cars	UK Road Use Distributions for Cars
Buses	UK Road Use Distributions for Buses
Light Goods Vehicles	UK Road Use Distributions for Light Goods Vehicles
Large HGV	UK Road Use Distributions for Large HGV
Small HGV	UK Road Use Distributions for small HGV
Motorcycles	UK Road Use Distributions for Motorcycles
Small Industry(< 50 mw)	SPRU Database Industrial Boiler Distributions
Ports	Port Activity Stats. for coastal Shipping and other UK Shipping
Agriculture	UK Land use Data and Livestock Populations
Domestic	Population Distrib. (Inc. Allowances for Gas Usage and Smoke Controlled Areas)
Miscellaneous	Distribution of Small Retail Outlets

Point sources are spatially identifiable and therefore do not require disaggregation. Emissions from these point sources can be included directly into the 10x10 km OS grid-square in which they are located.

To Represent total emissions the emission from each source are summed together for each grid-square. Point Source and area source emissions can also be represented separately, typically for modelling and more details spatial analysis. This allows special features of the point sources such a stack height to be utilised.

The NETCEN Air Quality Archive (http://www.aeat.co.uk/netcen/aqarchive/auto.html)

Data from the NETCEN sites listed in table # are used in this chapter. The data collection techniques for the NOx complex use chemiluminesence and for ozone UV photospectrometry. Most monitors record the hourly means and the maximum fifteen minute peaks for the substances however, some concern has been raised over the sighting of these monitoring stations as to weather these are best suited to gain accurate background readings(Air Health Strategy, December 1996 p10). Furthermore it should be remembered that a stationary monitor is not subjected to the same mobility patterns as a human being and therefore monitor exposure does not equate with personal expose since it is know that micro topography can have great influence on local pollution, levels (Air Health Strategy May 1996 1996).

NO_2 diffusion tube survey (http://www.aeat.co.uk/data/netcen/aqarchive/data/nonauto/*.html)

This survey is a joint effort between the DoE and Local Authorities within the United Kingdom to map spatial and temporal trends in concentrations throughout the UK. The programme is co-ordinated on behalf of the DoE by AEA Technology's, National Environmental Technology Centre (www -see detail92.html). Monitoring of NO_2 is carried out using the diffusion tube technique (see table 5.3-2) at four classes of location within the local authority area areas, these are

- Kerbside 1-5m from a busy road.
- Intermediate 20-30m from the same or an equivalent
- Background 50m from any busy road (2 Sites per local authority).

Since this section of the analysis is concerned with regional background patterns of this substance it will be the latter class of sites that will be used for the analysis of

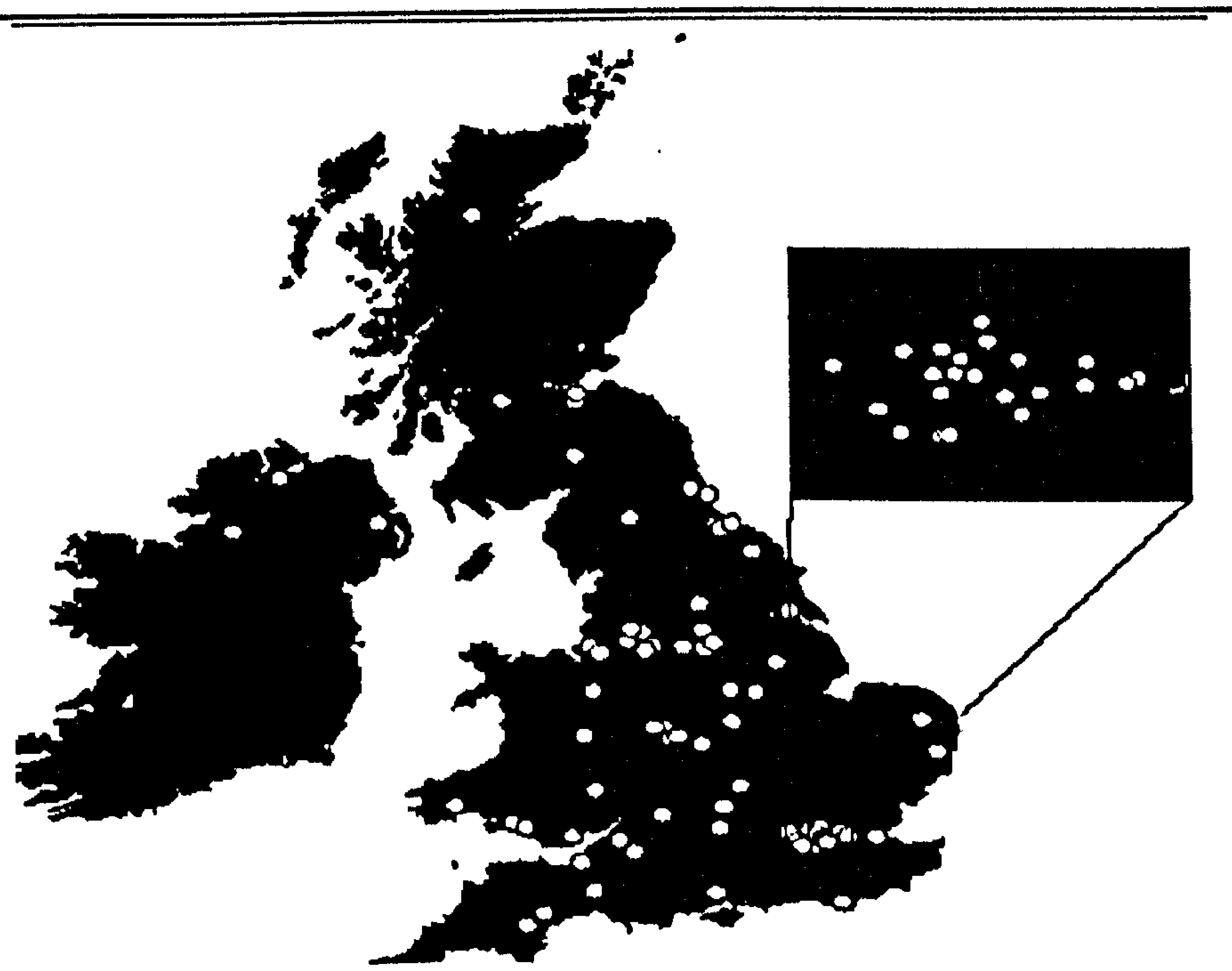

Figure 0.1. Automatic Motoring sited established by July 1997: note the poor coverage between London and Bedford.[1]

regional air pollution patterns. However kerbsite values will be used to illustrate areas where this pollution can be considered to be of levels that are legislatively important under the 1995 Environment Act (part IV), since these are important with regards to the pollution levels that people may be exposed to. However, it should be noted that the resolution of data from the NO_2 diffusion tube survey is different to that expressed in UK legislation (see chapter 6). A full description of the monitoring equipment and mapping protocol can be found in (Campbell 1994).

[1] after: DoE (1997) http://www.aeat.co.uk/netcen/aqarchive/auto/sitejune.gif.

Local Authority Data

Local data supplied by Bedford Borough Council was used to supplement the above data sets, particularly one hour ultra violet spectrometry monitoring data for the period of June to September 1996 and VOC monitoring data for Bedford 1994.

The ozone data was taken by a council sponsored monitoring of the city using an O_3 UV spectrometry [Stacey, 1994 #848] situated on the southern outskirts of the town and only covers the summer months (where O_3 concentrations tend to be high). However the low scale resolution of this data does allow for a good insight to the profile for O_3 pollution for this year.

Appendix 4. Tables and Results from Chapter 6

Questionaire

Cranfield University are carrying out a study to investigate the reasons why people generally prefer to use private motor as opposed to public transport. To assist this study I would be extremely grateful if you would complete the following short questionnaire

Personal Details (Confidential)

male ○ female ○

What age group are you (please circle) ?

17 -25 26 -35 46 - 55 56-65 65+

What is your place of residence ? ____________

What is the first half of your postcode ? ☐☐☐☐

About your car

What vehicle do you own/have access to

Type/Make/year ____________________

How long have you been driving for ? ____________

Are you the registered owner of the vehicle ? yes ○ no ○

if no who is ____________

How long have you had access to a vehicle ? ____________

How often do you drive ?

regularly often very often

How do you rate public transport provision in your area ?

poor satisfactory good

Do you prefer the use of private transport rather than public, if so why ?

____

____

____

____

____

How important do you find the following in you decision to choose private transport ?

Please rate in terms of importance.

	not important 1	2	3	4	very important 5
cost of transport					
personal security					
access					
privacy					
comfort					
flexibility					
status					
being in control of the vehicle					

Thank you very much for your co-operation

Appendix 4.1 Comparison of Mean Tables Listed by Dependent Variable

Appendix 4.1.1 Sex (*Total Cases = 358 Missing Cases = 8 or 2.2 Pct*)

Table 4.1-1:access

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		4.5486	0.8200	0 350
Sex	female	4.5796	0.7690	0 157
Sex	male	4.5233	0.8604	0 193

Table 4.1-2: comfort

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.4600	1.1592	350
Sex	female	3.4904	1.1130	157
Sex	male	3.4352	1.1977	193

Table 4.1-3: Cost of transport

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.1886	1.3851	350
Sex	female	3.3567	1.2761	157
Sex	male	3.0518	1.4568	193

Table 4.1-4: Being in control of the vehicle

Variable	Value Label	Mean	Std Dev	Cases
For Entire population		2.5272	1.4942	349
Sex	female	2.5159	1.4746	157
Sex	male	2.5365	1.5139	192

Table 4.1-5: Summaries of flexibility by levels of sex

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		4.5943	.8125	350
Sex	1	4.6752	.6814	157
Sex	2	4.5285	.9017	193

Table 4.1-6: Personal security

Variable	Value Label	Mean	Std Dev	Cases
For entire Population		3.2114	1.4206	350
Sex	female	4.0701	1.0135	157
Sex	male	2.5130	1.3194	193

Table 4.1-7 privacy

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		2.8886	1.2607	350
Sex	female	2.9045	1.1479	157
Sex	male	2.8756	1.3483	193

Table 4.1-8 status

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		1.8314	1.1862	350
Sex	female	1.7006	1.0468	157
Sex	male	1.9378	1.2814	193

Appendix 4.1.2 Age Group (Total Cases = 358 Missing Cases = 7 or 2.0 Pct)

Table 4.1-9: Access

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		4.5499	0.8192	351
Age Group	17-25	4.4894	0.7481	47
Age Group	26-35	4.4762	0.9104	105
Age Group	36-45	4.5694	0.8019	72
Age Group	46-55	4.6984	0.5575	63
Age Group	56-65	4.5313	1.0468	32
Age Group	over 65	4.5625	0.8400	32

Table 4.1-10: Comfort

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.4644	1.16	351
Age Group	17-25	3.6170	0.42	47
Age Group	26-35	3.2571	1.15	105
Age Group	36-45	3.3611	0.30	72
Age Group	46-55	3.3968	0.23	63
Age Group	56-65	3.9063	0.28	32
Age Group	over 65	3.8438	1.90	32

Table 4.1-11: Cost of transport

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.1937	3.1387	351
Age Group	17-25	3.5106	1.4122	47
Age Group	26-35	3.3333	1.3775	105
Age Group	36-45	3.0417	1.3368	72
Age Group	46-55	3.0476	1.3128	63
Age Group	56-65	3.5313	1.4588	32

Age Group	over 65	2.5625	1.3664	32

Table 4.1-12: Being in Control of the Vehicle

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		2.5314	1.4942	350
Age Group	17-25	3.3043	1.4433	46
Age Group	26-35	2.3714	1.5144	105
Age Group	36-45	2.2639	1.3426	72
Age Group	46-55	2.4921	1.5227	63
Age Group	56-65	2.3750	1.4312	32
Age Group	over 65	2.7813	1.5395	32

Table 4.1-13: Flexibility

Variable	Value Label	Mean	Std Dev	Case
For Entire Population		4.5954	0.8116	351
Age Group	17-25	4.6383	0.7048	47
Age Group	26-35	4.5714	0.8864	105
Age Group	36-45	4.7222	0.5366	72
Age Group	46-55	4.7619	0.4988	63
Age Group	56-65	4.5938	0.8747	32
Age Group	over 65	4.0000	1.2952	32

Table 4.1-14: Personal Security

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.2165	1.4218	351
Age Group	1	2.9149	1.3486	47
Age Group	2	3.2381	1.4245	105
Age Group	3	3.2639	1.2333	72
Age Group	4	3.2698	1.5049	63
Age Group	5	3.5000	1.5862	32
Age Group	6	3.0938	1.5935	32

Table 4.1-15: Privacy

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		2.8946	1.264	351
Age Group	17-25	3.4681	1.316	47
Age Group	26-35	2.7429	1.316	105
Age Group	36-45	2.9167	1.031	72
Age Group	46-55	2.7460	1.191	63
Age Group	56-65	3.0000	1.218	32
Age Group	over 65	2.6875	1.491	32

Table 4.1-16: Status

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		1.8348	1.1861	351
Age Group	17-25	2.5106	1.5162	47
Age Group	26-35	1.8190	1.1667	105
Age Group	36-45	1.8056	1.0830	72
Age Group	46-55	1.7460	1.1212	63
Age Group	56-65	1.4375	0.7594	32
Age Group	over 65	1.5313	1.0772	32

Appendix 4.1.3 Economic Grading (Total Cases = 358 Missing Cases = 17 or 4.7 Pct)

Table 4.1-17Access

Variable		Value label	Mean	Std Dev	Cases
For Entire Population			4.5630	0.8042	341
Economic rating	1	over 15,000	4.2500	0.9653	12
Economic rating	2	15,000 - 10,000	4.4000	1.0347	35
Economic rating	3	10, 000 - 6,000	4.6364	0.6936	66
Economic rating	4	6,000- 3,000	4.5169	0.8409	89
Economic rating	5	3,000-1,000	4.5823	0.8103	79
Economic rating	6	under 1,000	4.6833	0.6507	60

Table 4.1-18 Comfort

Variable		Value Label	Mean	Std Dev	Cases
For Entire Population			3.4721	1.1491	341
Economic rating	1	over 15,000	3.9167	1.0836	12
Economic rating	2	15,000 - 10,000	3.5714	1.3125	35
Economic rating	3	10, 000 - 6,000	3.4091	1.1499	66
Economic rating	4	6,000- 3,000	3.5618	1.0220	89
Economic rating	5	3,000-1,000	3.3671	1.1567	79
Economic rating	6	under 1,000	3.4000	1.2378	60

Table 4.1-19 Cost of transport

Variable		Value Label	Mean	Std Dev	Cases
For Entire Population			3.1848	1.3926	341
Economic rating	1	over 15,000	2.4167	1.2401	12

Economic rating	2	15,000 - 10,000	2.3143	1.1317	35
Economic rating	3	10, 000 - 6,000	3.3636	1.4532	66
Economic rating	4	6,000- 3,000	2.8876	1.3352	89
Economic rating	5	3,000-1,000	3.3671	1.3976	79
Economic rating	6	under 1,000	3.8500	1.1619	60

Table 4.1-20 Being in control of the vehicle

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			2.5314	1.4942	350
Economic rating	1	over 15,000	2.5273	1.4511	55
Economic rating	2.	15,000 - 10,000	2.5897	1.5600	117
Economic rating	3	10, 000 - 6,000	2.4468	1.4266	47
Economic rating	4	6,000- 3,000	2.5115	1.4903	131
Economic rating	5	3,000-1,000			
Economic rating	6	under 1,000			

Table 4.1-21 Flexibility

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		4.6070	0.7958	341
Economic rating	over 15,000	4.6667	0.4924	12
Economic rating	15,000 - 10,000	4.5143	1.0396	35
Economic rating	10, 000 - 6,000	4.5455	0.7271	66
Economic rating	6,000- 3,000	4.6292	0.7889	89
Economic rating	3,000-1,000	4.6076	0.8831	79
Economic rating	under 1,000	4.6833	0.6507	60

Table 4.1-22 Personal security

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			3.2287	1.4102	341
Economic rating	1	over 15,000	3.5000	1.6237	12
Economic rating	2	15,000 - 10,000	2.8571	1.4979	35
Economic rating	3	10, 000 - 6,000	3.3636	1.3546	66
Economic rating	4	6,000- 3,000	3.2584	1.4185	89
Economic rating	5	3,000-1,000	3.3671	1.3884	79
Economic rating	6	under 1,000	3.0167	1.3838	60

Table 4.1-23 Privacy

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		2.9032	1.2553	341
Economic rating	over 15,000	.5833	1.4434	12
Economic rating	15,000 - 10,000	.3143	1.4302	35

Economic rating	10, 000 - 6,000	.0303	1.3123	66
Economic rating	6,000- 3,000	.7079	1.1985	89
Economic rating	3,000-1,000	.8354	1.2135	79
Economic rating	under 1,000	.7667	1.1103	60

Table 4.1-24 Status

Variable		Value Label	Mean	Std Dev	Cases
For Entire Population			1.8387	1.1834	341
Economic rating	1	over 15,000	2.6667	1.6143	12
Economic rating	2	15,000 - 10,000	2.1714	1.4035	35
Economic rating	3	10, 000 - 6,000	1.8182	1.1356	66
Economic rating	4	6,000- 3,000	1.8202	1.1828	89
Economic rating	5	3,000-1,000	1.5949	0.9677	79
Economic rating	6	under 1,000	1.8500	1.1907	60

Appendix 4.1.4 **Resdential area** *(Total Cases = 358 Missing Cases = 7 or 2.0 Pct)*

Table 4.1-25 Access

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		4.5499	.8192	351
Residency	large city	4.3636	.7785	55
Residency	small city/lge town	4.3333	1.0422	117
Residency	small town	4.9149	.2821	47
Residency	village	4.6894	.6554	132

Table 4.1-26 Comfort

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.4644	1.1604	351
Residency	city	3.6000	1.1483	55
Residency	sm.city/lge town	3.3077	1.2280	117
Residency	small town	3.8298	1.1096	47
Residency	village	3.4167	1.0985	132

Table 4.1-27 Cost of transport

Variable	Value Label	Mean	Std Dev	Cases
For Entire Population		3.1937	1.3865	351

Missing pages are unavailable

Mean	age group	6	2	5	1	3
4.0000	Grp 6					
4.5714	Grp 2	*				
4.5938	Grp 5	*				
4.6383	Grp 1	*				
4.7222	Grp 3	*				
4.7619	Grp 4	*				

(*) Indicates significant differences

Table 4.2-5 Personal Security by Age Group

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	7.7194	1.5439	.7611	.5784
Within Groups	345	699.8248	2.0285		
Total	350	707.5442			

The difference between two means is significant if MEAN(J)-MEAN(I) >= 1.0071 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-6 Being in Control of the Vehicle by Age Group

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	38.2000	7.6400	3.5470	.0039
Within Groups	344	740.9543	2.1539		
Total	349	779.1543			

Multiple Range Tests: LSD test with significance level .05 The difference between two means is significant if MEAN(J)-MEAN(I) >= 1.0378 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-7 Being in Control of the Vehicle by Age Group (LSD)

Mean	age group	3	2	5	4	6	1
2.2639	Grp 3						
2.3714	Grp 2						
2.3750	Grp 5						
2.4921	Grp 4						
2.7813	Grp 6						
3.3043	Grp 1	*	*	*	*		

(*) Indicates significant differences

Table 4.2-8 Privacy by age group

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	21.0289	4.2058	2.6967	.0209

Within Groups	345	538.0708	1.5596
Total		350.	559.0997

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if MEAN(J)-MEAN(I) > = .8831 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78.

Table 4.2-9 Privacy by levels of age group (LSD)

Mean	Age Group	6	2	4	5	1
2.6875	Grp 6					
2.7429	Grp 2					
2.7460	Grp 4					
2.9167	Grp 3					
3.0000	Grp 5					
3.4681	Grp 1	*	*	*	*	

(*) Indicates significant differences

Table 4.2-10 Status by age group (Analysis of Variance)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	30.0513	6.0103	4.4846	.0006
Within Groups	345	462.3646	1.3402		
Total	350	492.4160			

Multiple Range Tests: LSD test with significance level .05 The difference between two means is significant if MEAN(J)-MEAN(I) >=.8186 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-11 Status by age group (LSD)

Mean	age group	5	6	4	3	2	1
1.4375	Grp 5						
1.5313	Grp 6						
1.7460	Grp 4						
1.8056	Grp 3						
1.8190	Grp 2						
2.5106	Grp 1	*	*	*	*	*	

(*) Indicates significant differences

Appendix 4.2.2 Cost

Table 4.2-12 Cost Of Transport by Economic Grading

Source	D.F.	Sum of	Mean Squares	F Ratio	F Prob.

Between Groups	5	72.7476	14.5495	8.3089	.0000
Within Groups	335	586.6131	1.7511		
Total	340	659.3607			

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if: MEAN(J)-MEAN(I) > = .9357 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-13 Cost Of Transport by Economic Grading

Mean	Economic Grading	2	1	4	3	5	6
2.3143	Grp 2						
2.4167	Grp 1						
2.8876	Grp 4	*					
3.3636	Grp 3	*	*	*			
3.3671	Grp 5	*	*	*			
3.8500	Grp 6	*	*	*	*	*	

* indicates a 95% probability that there is a significant difference between group variances

Table 4.2-14 Personal Security by Economic Grading (LSD)

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	11.2060	2.2412	1.1291	.3446
Within Groups	335	664.9524	1.9849		
Total	340	676.1584			

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if MEAN(J)-MEAN(I) >= .9962 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

- No two groups are significantly different at the .05 level

Table 4.2-15 Privacy by Economic Grading

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	17.4089	3.4818	2.2500	.0492
Within Groups	335	518.3975	1.5475		
Total		340	535.8065		

Multiple Range Tests: LSD test with significance level .05
The difference between two means is significant if MEAN(J)-MEAN(I) >= .8796 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-16 Privacy by Economic Grading (LSD)

Mean	economic grading	4	6	5	3	2	1
2.7079	Grp 4						
2.7667	Grp 6						
2.8354	Grp 5						
3.0303	Grp 3						
3.3143	Grp 2	*	*				
3.5833	Grp 1	*	*				

(*) Indicates significant differences

Table 4.2-17 Flexibility By Economic Grading

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	.9871	.1974	.3085	.9077
Within Groups	335	214.3560	.6399		
Total	340	215.3431			

Multiple Range Tests: LSD test with significance level .05 The difference between two means is significant if MEAN(J)-MEAN(I) >= .5656 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

LSD showed that was that - No groups are significantly different at the .05 level

Table 4.2-18 Status by economic grading

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	5	16.8612	3.3722	2.4598	.0330
Within Groups	335	459.2678	1.3709		
Total	340	476.1290			

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if MEAN(J)-MEAN(I) >= .8279 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-19 Status by economic grading (LSD)

Mean	ECONOMIC		5	3	4	6	2	1
1.5949	Grp	5						
1.8182	Grp	3						
1.8202	Grp	4						
1.8500	Grp	6						
2.1714	Grp	2	*					
2.6667	Grp	1	*	*	*			

(*) Indicates significant differences

Appendix 4.2.3 Residentail Area

Figure 4.2-1 Cost Of Transport by Resdential area

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	14.7246	4.9082	2.5880	.0529
Within Groups	347	658.1016	1.8965		
Total	350	672.8262			

Multiple Range Tests: LSD test with significance level .05

The difference between two means is significant if MEAN(J)-MEAN(I) > = .9738 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-20 Cost Of Transport by Resdential area (LSD)

Mean	Residency	1	2	4	3
2.7818	Grp 1				
3.1624	Grp 2				
3.2879	Grp 4	*			
3.4894	Grp 3	*			

(*) Indicates significant differences which are shown in the lower triangle

Table 4.2-21 Personal Security by Resdential area

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	14.5474	4.8491	2.4281	.0652
Within Groups	347	692.9967	1.9971		
Total	350	707.5442			

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if MEAN(J)-MEAN(I) >= .9993 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78

Table 4.2-22 Personal Security by Resdential area (LSD)

Mean	resdential area	1	4	2	3
2.7455	Grp 1				
3.2955	Grp 4	*			
3.2991	Grp 2	*			
3.3404	Grp 3	*			

(*) Indicates significant differences which are shown in the lower triangle

Table 4.2-23 Access by Resdential area

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.

Between Groups	3	16.2255	5.4085	8.5833	.0000
Within Groups	347	218.6520	0.6301		
Total	350	234.8775			

Multiple Range Tests: LSD = at significance .05

The difference between two means is significant if MEAN(J)-MEAN(I) > = .5613 * RANGE * SQRT(1/N(I) + 1/N(J)). With the following value(s) for RANGE: 2.78(*) Indicates significant differences which are shown in the lower triangle.

Table 4.2-24 Access by Resdential area (LSD)

Mean	residency	2	1	4	3
4.3333	Grp 2				
4.3636	Grp 1				
4.6894	Grp 4	*	*		
4.9149	Grp 3	*	*		

Table 4.2-25 Flexibility By Resdential area

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	12.5685	4.1895	6.6691	.0002
Within Groups	347	217.9842	.6282		
Total	350	230.5527			

Multiple Range Tests: LSD test with significance level .05. The difference between two means is significant if MEAN(J)-MEAN(I) >= .5604 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78.

Table 4.2-26 Flexibility By Resdential area (LSD)

Mean	RESIDENCY	1	2	4	3
4.4000	Grp 1				
4.4103	Grp 2				
4.7424	Grp 4	*	*		
4.8723	Grp 3	*	*		

(*) Indicates significant differences which are shown in the lower triangle

Table 4.2-27 Status By Resdential area

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	10.8445	3.6148	2.6047	.0517
Within Groups	347	481.5715	1.3878		
Total	350	492.4160			

Multiple Range Tests: LSD test with significance level .05

The difference between two means is significant if MEAN(J)-MEAN(I) >= .8330 * RANGE * SQRT(1/N(I) + 1/N(J)) with the following value(s) for RANGE: 2.78.

Table 4.2-28 Status by resdential area (LSD)

Mean	RESIDENCY	4	1	2	3
1.7045	Grp 4				
1.7636	Grp 1				
1.8462	Grp 2				
2.2553	Grp 3	*	*	*	

(*) Indicates significant differences which are shown in the lower triangle